

3.13 FISH AND AQUATIC RESOURCES

SYNOPSIS

Overview:

Fish and aquatic resources are of central importance to the livelihood of residents of the proposed project area. While other chapter sections—3.5 Surface Water Hydrology, 3.7 Water Quality, and 3.21 Subsistence—discuss topics associated with fish and aquatic resources, this section characterizes aquatic habitat and the diversity, abundance, and distribution of fish in the Kuskokwim River and the drainages affected by the proposed project. The section also describes the regulatory framework associated with the management and protection of area fisheries and aquatic habitats and presents an analysis of expected consequences of the proposed project and alternatives.

Background:

Regulatory Framework: Both federal and state laws protect fish and aquatic resources that would be affected by components of the proposed project. Key laws and regulations include the Clean Water Act, including Sections 402 and 404, which governs discharges to waters of the U.S.; the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act), which governs protection of Essential Fish Habitat (EFH); and state regulation of mining and water use and discharge permits as well as fish habitat protection requirements.

Fish Habitat, Abundance, and Diversity: The Kuskokwim River and many of its tributaries, including tributaries in the Crooked Creek drainage, are designated as EFH for Pacific salmon. In Crooked Creek, populations of Chinook, chum, and coho salmon and limited numbers of sockeye and pink salmon have been recorded. In addition, 12 species of resident fish, including Dolly Varden, rainbow trout, Arctic grayling, burbot, and two species of whitefish, have been documented in Crooked Creek. Figure 3.13-1 shows the Crooked Creek drainage, relative to the proposed mine site area, with various reaches of Crooked Creek and its tributaries color-coded for salmon type and densities and other labels identifying species distribution.

The proposed transportation corridor includes roughly 168 miles of the Kuskokwim River (Figure 3.13-2). This aquatic habitat is characterized by sediment-rich, low-gradient, meandering channels of water depth that fluctuates with tides and seasons. Changing flow paths create sandbars and erode riverbanks. Downed trees line many eroding banks and provide refuge for fish. The shallowest stretches of the proposed transportation corridor generally lie upstream of Kalskag. At least 27 species of anadromous and resident freshwater fish are found in the Kuskokwim River drainage. Chinook salmon are a special concern in

recent years due to low populations, but no endangered or threatened fish species are found in the Kuskokwim River drainage.

Fisheries: The Kuskokwim River subsistence fishery is one of the largest in Alaska. The Kuskokwim drainage contains about 4,600 households within 38 communities. More than 1,500 households engage in subsistence fishing, and the catch is shared with more still. Subsistence salmon fishing on the Kuskokwim has not involved licenses or permits beyond the requisite year of Alaska residency. Although there are generally no limits on individual or household take of subsistence salmon, urgent conservation measures have limited harvest of Chinook salmon in recent years. See Section 3.21, Subsistence, for further details. Table 3.13-14 through Table 3.13-17 and Table 3.13-19 give a view of relative Kuskokwim commercial and subsistence harvests of salmon species over time, with subsistence use of Chinook and sockeye predominating over commercial takes. Commercial harvest of chum is generally greater than subsistence, and commercial use of coho far outweighs subsistence harvest. Sport fisheries also occur in this part of the Kuskokwim, and both commercial and subsistence use of aquatic resources extend into Kuskokwim Bay.

Expected Effects:

Alternative 2: Donlin Gold's Proposed Action –

Mine Site: The proposed mine would affect migration, spawning, or rearing life stages of Pacific salmon and other anadromous or resident fish species and aquatic habitat through direct habitat removal, wetland removal, stream flow and temperature changes, and sedimentation. Streams in the Crooked Creek drainage near the mine site support Chinook, coho, chum, pink, and sockeye salmon. Just under 8 miles of streambed, (in American and Anaconda creeks and portions of Snow and Lewis gulches) would be eliminated to construct mine site facilities. These, and smaller tributary drainages that would be affected, represent about 8 percent of the Crooked Creek watershed. Most of the segments that would be filled in these tributaries do not support salmon, but in some years, habitat in American Creek supports up to 200 age 0 and age 1 juvenile coho salmon, which would be lost. Stream flow changes would be seasonal, with greatest reductions during winter months, affecting resident fish and overwintering coho salmon. The greatest effects of flow reductions and temperature increase in Crooked Creek would occur upstream of Crevice Creek. Below this, tributary inflows/runoff from unaffected watersheds (e.g., Bell and Getmuna creeks) would overshadow flow reductions resulting from mine site development and operations. Permit-mandated water management practices at the mine site would help avoid and mitigate effects on downstream aquatic resources, including EFH. The overall effect of the mine site component on fish and aquatic resources of the Crooked Creek drainage is expected to be moderate.

Transportation Facilities: Depending on water conditions, barge/tug wakes and propeller forces along the Kuskokwim River travel route may accelerate bank erosion and create riverbed scour, particularly in narrow and shallow segments of the river. This could degrade habitat and disturb or destroy fish eggs, larvae, or juveniles. Along the proposed access road,

six streams used by Chinook, coho, and chum salmon would be crossed with full-span bridges resulting in potential minor, temporary degradation of water quality that would be minimized by best management practices employed for construction and operations of roads, bridges, and culverts. Similar measures would be used to control potential water quality effects from construction and operation at the proposed port site. Because the nature and intensity of potential impacts of barge traffic would vary based on a range of factors, overall effects on fish and aquatic resources, which may be minor, are characterized conservatively as moderate.

Pipeline: Construction of the proposed natural gas pipeline could affect aquatic resources from habitat degradation and releases of turbid runoff at numerous crossings within the proposed construction corridor and along nearby stream corridors. Of the streams in the construction corridor, 77 contain habitat used by five species of Pacific salmon (i.e., Chinook, chum, coho, pink, and sockeye salmon). Effects would be limited and mitigated by horizontal directional drilling (HDD) at five of eight crossings constructed during summer months; timing pipe installation at most crossings in winter when salmon are not typically present, resulting in least disruption to aquatic resources; and employing best management practices during and post construction to minimize potential effects. The overall effect of the pipeline component on fish and aquatic resources is expected to be minor.

Other Alternatives: The effects of other alternatives on fish and aquatic resources would be similar to those of Alternative 2. Differences of note involve three of the alternatives:

- Alternative 3A (LNG-Powered Haul Trucks) would decrease the total number of barge trips per season from 122 to 83. This would result in a proportionate decrease in potential impacts on young-of-year seaward migrating salmon, incubating rainbow smelt eggs, and other life stages of resident and anadromous fishes in certain segments of the Kuskokwim River as a result of barge-generated propeller forces, waves, bank erosion, and riverbed scour.
- Alternative 3B (Diesel Pipeline) would eliminate fuel barging on the Kuskokwim River after the construction phase, reducing the total number of barge trips per season from 122 to 64. This also would result in a proportionate decrease in potential impacts on young-of-year seaward migrating salmon, incubating rainbow smelt eggs, and other life stages of resident and anadromous fishes in certain segments of the Kuskokwim River as a result of barge-generated propeller forces, waves, bank erosion, and riverbed scour.
- Alternative 4 (Birch Tree Crossing Port) would eliminate the upriver portion of the river route, replacing it with a longer mine access road and fewer stream crossings than Alternative 2. Under this alternative, fewer impacts associated with a shorter distance of travel along the Kuskokwim River barge route might be offset by greater impacts from roadfills that could affect wetland and riparian communities along a more extended roadway corridor.

3.13.1 REGULATORY FRAMEWORK

Federal and state government agencies regulate developments within aquatic habitats, which include in-water construction (port development and expansion), stream crossings (port to mine road and pipeline), dam construction, water diversions, and discharges at the Donlin Gold mine site area. Numerous permits and authorizations are required as summarized below:

3.13.1.1 FEDERAL

- The U.S. Army Corps of Engineers (Corps)
 - Under Section 10 of the Rivers and Harbors Act, the Corps regulates navigable waters of the United States, which includes all waters within the Kuskokwim River below the ordinary high water mark. Construction of structures and activities that affect the course, conditions, location, or navigable capacity of the river would require a Section 10 Permit.
 - Under Section 404 of the Clean Water Act, the Corps is responsible for maintaining the chemical, physical, and biological integrity of the Nation's waters. Any discharge of dredged or fill materials into jurisdictional waters of the United States may require a Section 404 Permit. This would include construction of roads, bridges, or pipeline crossings at streams, construction of dams for tailings storage, water storage dams, stream diversion structures, and port development/expansion at existing marine terminals at Dutch Harbor and Bethel or at new port facilities on the Kuskokwim River.
- NMFS is responsible for protecting habitats important to federally managed marine species, which includes anadromous Pacific salmon. Federal agencies must consult with NMFS concerning any action that may adversely affect EFH under the Magnuson-Stevens Act. EFH includes habitats necessary to a species for spawning, breeding, feeding, or growth to maturity, which includes marine and riverine migratory corridors, spawning grounds, and rearing areas of the Pacific salmon species.
- The U.S. Coast Guard (USCG) is responsible for Vessel Response Plans (VRP) and Facility Response Plans (FRP) which are required under the Oil Pollution Act of 1990, to minimize the impact of oil spills.
- The U.S. Environmental Protection Agency (EPA) has review and oversight authority over Section 404 Permit decisions under the Clean Water Act and the Spill Prevention, Control, and Countermeasure (SPCC) Plan required for oil storage. Facilities with above and underground storage facilities with capacities that would exceed a specific threshold are required to develop and implement a SPCC Plan.

3.13.1.2 STATE

- The Alaska Department of Natural Resources (ADNR) coordinates the permitting of large mine projects in the state, including the integration of federal and local government agencies. ADNR develops a large mine project team, an interagency group that works cooperatively with large mine applicants and operators, federal agencies, and the public to ensure that projects are designed, operated, and reclaimed in a manner

consistent with the public interest. Specific permits and approvals for work in aquatic habitats include:

- **Permit to Appropriate Water.** Appropriation of a significant amount of water on other than a temporary basis requires authorization by a Water Rights Permit. A Water Right is a property right for the use of public surface and subsurface waters. Temporary uses of a significant volume of water, for up to 5 years, require a Temporary Water Use Authorization (TWUA).
- **Dam Safety Certification.** A Certificate of Approval to Construct and a Certificate of Approval to Operate must be obtained for any significant dam in the State, including tailings storage facilities and contact water or fresh water storage reservoirs. These certificates involve a detailed engineering review of the dam's design and operation.
- **Upland or Tideland Leases.** A project may require a property interest in lands not adjacent to the mine site itself. For use of state-owned tidelands, a tideland lease is issued for marine facilities such as docks or wharfs. Likewise, for use of state-owned uplands, a lease is required for facilities such as transportation and staging facilities or material sites.
- **Reclamation Plan and Financial Assurance Approval.** This approval authorizes the reclamation plan and financial assurance for non-coal mines in Alaska. It specifies that mine sites must be returned to a stable condition, compatible with post-mining land use. Financial assurance must ensure that the state of Alaska can do the reclamation if the applicant cannot.
- **The Alaska Department of Environmental Conservation (ADEC) administers the following programs involving aquatic habitats:**
 - **Waste Management Permit.** If tailings or waste rock from a mine project has the potential for impacting state waters, then a Waste Management Permit must be obtained. This permit usually requires pre-operational, operational, and post closure monitoring. The permit also requires financial assurance both during and after operations, and to cover short and long-term treatment if necessary, closure costs, monitoring, and maintenance needs.
 - **Alaska Pollutant Discharge Elimination System Permit.** ADEC regulates mine discharges to all waters under the Alaska Pollutant Discharge Elimination System program (APDES). All mines that have a discharge to waters of the U.S. are required to obtain an APDES permit prior to discharging. Under this program, new mine discharges are required to meet applicable New Source Performance Standards and State water quality standards. These include standards for protection of aquatic life in the receiving water. APDES permits require regular monitoring to ensure compliance with discharge limitations and often include other stipulations to protect water quality.
 - **Domestic and Non-Domestic Wastewater Disposal Permits.** ADEC authorizes the discharge of wastewater into or upon all waters and land surfaces of the state. If injection wells are part of the wastewater disposal plan, then the requirements for EPA's Underground Injection Control (UIC) Class V wells must be met in addition to any requirements in a state wastewater permit.

- Certificate of Reasonable Assurance for 404 Permits. Activities involving dredging or discharge of fill material within waters of the United States are governed by the terms and conditions of a CWA Section 404 Permit from the Corps. CWA Section 401 also requires the applicant to obtain state certification that any discharge under CWA Section 404 will comply with applicable state water quality standards.
- Storm Water Discharge Pollution Prevention Plan. ADEC administers the APDES Storm Water General Permit for construction activities, and, during the operational phase of facilities, the APDES Multi-sector General Permit for industrial activities. ADEC approves Storm Water Pollution Prevention Plans (SWPPPs) that include storm water best management practices (BMPs). The facility may have separate APDES permits to cover waste water and storm water discharges, or the requirements may be combined into one APDES permit.
- Oil Discharge Prevention and Contingency Plan. Approval of an Oil Discharge Prevention and Contingency Plan is required prior to commencement of operation of non-tank vessels greater than 400 gross tons and oil barges on state waters, or for above ground tank facilities capable of storing 420,000 or more gallons of refined petroleum product or 210,000 or more gallons of crude oil. These contingency plans are reviewed every 3 years.
- The Alaska Department of Fish and Game (ADF&G) has the statutory responsibility for protecting freshwater anadromous fish habitat and ensuring free passage for anadromous and resident fish in fresh water bodies. Any activity or project that has the potential to impede or prohibit fish passage or is conducted below the ordinary high water mark of an anadromous stream requires a Title 16 Fish Habitat Permit. A Fish Habitat Permit is required before any action is taken to construct a hydraulic project; use, divert, obstruct, pollute, or change the natural flow or bed of a specified river, lake, or stream; or use wheeled, tracked, or excavating equipment or log-dragging equipment in the bed of a specified river, lake, or stream. A Fish Habitat Permit also is required for water withdrawals related to construction of ice bridges or roads, water diversion/dewatering operations, or hydraulic testing of pipelines. A water withdrawal includes any operation in which water is pumped from a stream. Specific screening requirements for the pump intake are specified in the permit to avoid fish entrainment, impingement, or injury.

3.13.1.3 LOCAL

Additional local permits with requirements that would protect fish and aquatic resources also may be required. The mining footprint is in a highly remote location near the community of Crooked Creek (population of approximately 100). Aniak (population of approximately 600), the regional transportation center of the middle Yukon-Kuskokwim Valley, is located approximately 60 miles downstream of the mine footprint. Bethel (population of approximately 6,000), the administrative and transportation center of the Yukon-Kuskokwim Delta, is located approximately 180 miles downstream of the proposed mine. Local permit requirements not related to State and Federal authorizations may govern temporary and permanent employment, housing, transportation, access and preservation of subsistence fisheries, and other cultural issues.

3.13.2 AFFECTED ENVIRONMENT

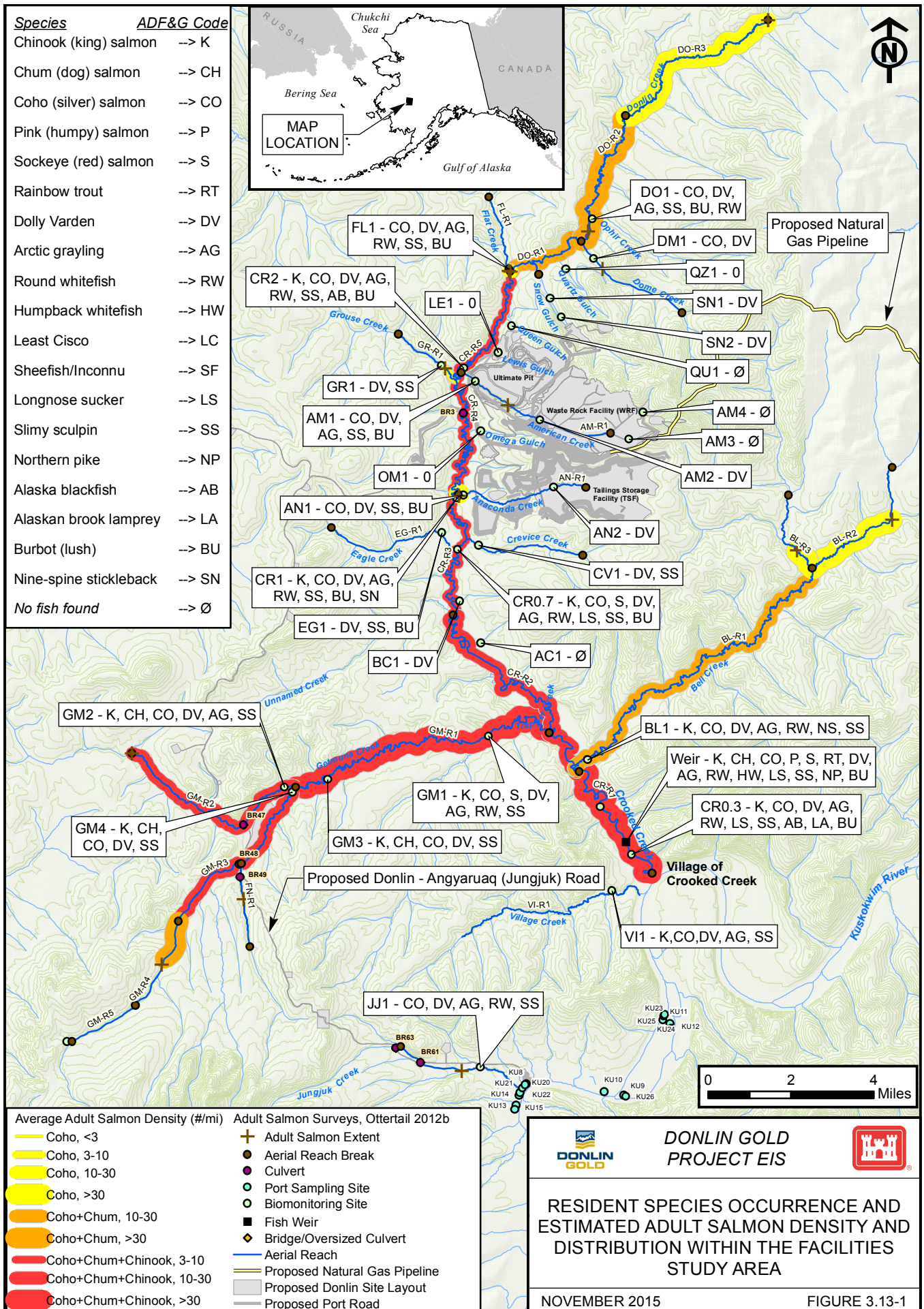
The following is a description of fish and aquatic biota within the proposed project area that may be affected by the Donlin Gold Project. This includes freshwater and marine species (e.g., fish, macroinvertebrates, algae) and their associated aquatic habitats. Potential effects would be associated with the three primary components of the project: (1) the mine site area (Figure 3.13-1 and Figure 2.3-1, Chapter 2, Alternatives); (2) the transportation corridor extending from an existing marine terminal in Dutch Harbor to Kuskokwim Bay, up the Kuskokwim River to a new port site (either Angyaruaq (Jungjuk) or Birch Tree Crossing), then inland to the mine along a new road (Figure 3.13-2, and Figures 2.3-11, 2.3-12, 2.3-41, and 2.3-42 in Chapter 2, Alternatives); and (3) the pipeline route extending from Cook Inlet to the mine (Figure 2.3-14, Chapter 2, Alternatives). Ice roads associated with construction of the pipeline (or the mine access road under Alternative 4) would affect additional area and streams. The mainstem Kuskokwim River, which is subject to intense flooding, natural bed scours, and ice-out conditions, primarily serves as a migration corridor to anadromous salmon stocks traveling between Kuskokwim Bay and upriver tributaries of the Kuskokwim watershed. These tributaries are important to all salmon life stages by providing habitat more suitable for spawning, overwintering, and rearing. Although primarily serving as a salmon migration corridor, the Kuskokwim mainstem also provides important habitat to life stages of various other anadromous and resident fishes.

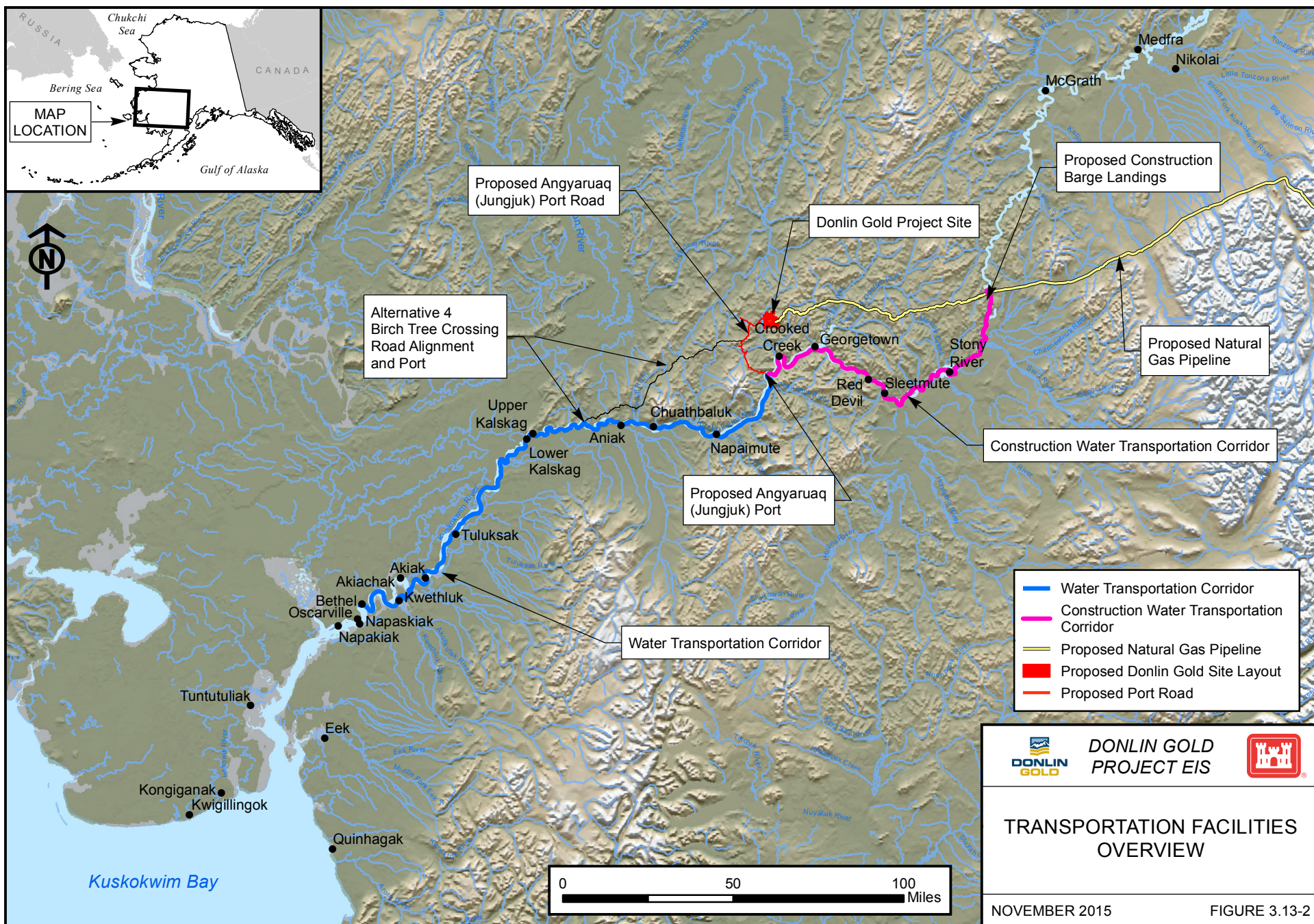
3.13.2.1 MINE SITE AREA – CROOKED CREEK DRAINAGE

The proposed mine site area encompasses the primary mining operation area including the WRF, TSF, the mine pit itself, and associated facilities (Figure 3.13-1, and Figures 2.3-1 and 2.3-2 in Chapter 2, Alternatives). All activities that would occur within the mine site area are situated within the Crooked Creek drainage. Crooked Creek drains an area of 333 mi² (less than 1 percent of the 50,000 mi² Kuskokwim River watershed) and enters the Kuskokwim River at the Village of Crooked Creek. An intensive stream habitat survey was conducted in 2009 to document aquatic habitat throughout the Crooked Creek mainstem. Results from the 2009 and subsequent aquatic baseline surveys indicate there is a relatively high amount of natural silt/bed load in this drainage system compared to some of the other similarly sized drainages of the Kuskokwim River (OtterTail 2012b). Additionally, complete freezing during the late winter months has been documented in many of the tributary streams in the Crooked Creek drainage (OtterTail 2012b). The combination of high natural siltation and winter freeze-down limit the amount and quality of aquatic habitat in this drainage system.

3.13.2.1.1 AQUATIC HABITAT

The life stages of salmon and other anadromous and resident fish are dependent on a variety of aquatic habitat types and stream conditions. For the salmon life cycle, suitable habitat and stream conditions are required for adult upstream migration from river estuaries; for tributary spawning and egg incubation in gravel substrates along riffles; for feeding, rearing, and overwintering in tributary pools and off-channel backwater areas; and for seaward migration to complete their life cycle of rearing and growth in estuaries and the open ocean. The nature and extent of aquatic habitat in the Kuskokwim River, Crooked Creek, and other river/stream systems are largely defined by:





- flow and water quality regimes that reflect seasonally variable depths, velocities, channel configurations, nutrient loads, and stream temperatures;
- the availability and distribution of gravel-sized substrates with a limited amount of fines for fish spawning and aquatic insect production; and
- the availability and distribution of a mixture of instream and streamside rock, woody debris, and vegetative cover that provide suitable conditions for fish migration, refugia, and rearing.

Other related factors that influence the character of aquatic habitat in streams include channel slope and sinuosity; bedload composition and transport mechanisms; the extent of seasonal scouring from flooding, winter freeze and ice break up conditions; and hydraulic forces that affect the type, size, distribution, and quality of key habitat types (e.g., spawning riffles, pools, runs, off-channel rearing areas, and overwintering refuge areas). The combination of these and other factors determine the quality and extent of fish migration, spawning, and rearing essential to the production of salmon smolts, resident fishes, and diverse populations of aquatic prey species.

One of the most fundamental factors affecting aquatic habitat in streams is the flow regime or seasonal pattern of average discharge and the level of variation around that average (Quinn 2005). The flow regime, in combination with other factors as described above, determines the distribution, areal extent, and depth of riffles, pools, and off-channel habitat as well as the distribution of large woody debris all of which are of key importance to salmon production. Pool size and depth, in particular, affect overwinter survival for salmon and other resident fish when other shallower portions of streams completely freeze. The following sections describe the character of aquatic habitat for drainages within the upper, middle, and lower Crooked Creek watershed.

Upper Watershed

Donlin Creek, Flat Creek, and Dome Creek. The upper watershed consists of streams situated upstream of the confluence of Donlin Creek and Flat Creek (Figure 3.13-1). Donlin Creek (DO1) has a moderate gradient and relatively high sinuosity resulting in classic riffle-run-pool habitat types. Donlin Creek and its tributaries drain an area of 30.5 mi². Although heavy icing during winter results in some sections of the stream freezing solid, pool depth is generally sufficient to provide fish overwintering habitat. Gravel and cobble are the dominant substrates in riffles throughout much of the Donlin Creek mainstem (Table 3.13-1). Salmon spawning habitat is abundant throughout much of Donlin Creek, however, access to these habitats can be limited in certain years due to beaver activity (OtterTail 2012b).

Flat Creek (FL1) is smaller than Donlin Creek, draining an area of 19.5 mi² (Figure 3.13-1). A moderately high gradient and low sinuosity channel results in a prevalence of riffle-run habitats. The substrate is dominated by cobbles in the lower reaches, transitioning to sand and silt in the upper reaches (Table 3.13-1). Observations during the winter months suggest that Flat Creek has little or no upwelling. Under certain conditions, this may allow bottom freezing in portions of the creek (OtterTail 2011).

Table 3.13-1: Crooked Creek Watershed Stream Characteristics

Stream Name	Percent of Crooked Creek Watershed	Drainage Area (sq mi)	Aerial Reach	Site within Reach	Slope ¹ Percent	Sinuosity	Rosgen Type ²	Dominant Substrate in Riffles ³	AVG Wetted Width ⁴	
									ft	m
Donlin Creek	9.09	30.5	DO-R1	N/A	0.3	1.47	N/A	N/A	N/A	N/A
			DO-R2	DO1	0.4	1.82	B5c	gravel	19.9	6.1
			DO-R3	N/A	0.7	1.48	N/A	N/A	N/A	N/A
Dome Creek	2.03	6.8	DM-R1	DM1	2.6	1.06	G4	gravel/cobble	8.6	2.6
Quartz Gulch	0.35	1.2	N/A	QZ1	3.2	1.03	G3g	gravel/cobble	8.0	2.4
Snow Gulch	1.01	3.4	SN-R1	SN2	1.9	1.04	G6	sand	4.4	1.3
Queen Gulch	0.21	0.7	N/A	QU1	2.6	1.01	G3g	sand/gravel	6.6	2.0
Flat Creek	5.80	19.5	FL-R1	FL1	0.6	1.12	B3c	cobble	12.1	3.7
Lewis Gulch	0.23	0.8	N/A	LE1	4.4	1.01	G3g	gravel/cobble	2.5	0.8
American Creek	2.04	6.9	AM-R1	AM1	2.2	1.04	B5	gravel/cobble	10.5	3.2
			AM-R1	AM2	2.2	1.04	B5	gravel/cobble	13.1	4.0
Grouse Creek	3.56	12.0	GR-R1	GR1	0.9	1.07	B5c	gravel	13.2	4.0
Omega Gulch	0.30	1.0	N/A	OM1	4.5	1.06	G6da	silt/sand	3.3	1.0
Anaconda Creek	2.34	7.9	AN-R1	AN1	1.4	1.15	G6c	silt/sand	7.3	2.2
			AN-R1	AN2	1.4	1.15	G6c	silt/sand	7.4	2.3
Crevice Creek	2.01	6.8	CV-R1	CV1	0.7	1.14	B5c	gravel	5.3	1.6
Eagle Creek	2.53	8.7	EG-R1	EG1	1.0	1.05	G6c	silt/sand	5.0	1.5
Unnamed (BC)	0.10	0.4	N/A	BC1	2.8	1.03	G6da	sand	5.0	1.5
Unnamed (AC)	0.08	0.3	N/A	AC1	2.3	1.04	G6da	sand	3.0	0.9
Bell Creek	21.23	71.3	BL-R1	BL1	0.4	1.68	C4	gravel/cobble	29.5	9.0
			BL-R2	N/A	1.2	1.21	N/A	N/A	N/A	N/A

Table 3.13-1: Crooked Creek Watershed Stream Characteristics

Stream Name	Percent of Crooked Creek Watershed	Drainage Area (sq mi)	Aerial Reach	Site within Reach	Slope ¹ Percent	Sinuosity	Rosgen Type ²	Dominant Substrate in Riffles ³	AVG Wetted Width ⁴	
									ft	m
			BL-R3	N/A	1.0	1.26	N/A	N/A	N/A	N/A
Getmuna Creek	29.39	98.6	GM-R1	GM1	0.4	1.65	C4	gravel/cobble	51.6	15.7
			GM-R2	N/A	0.5	1.39	N/A	N/A	N/A	N/A
			GM-R3	N/A	1.0	1.20	N/A	N/A	N/A	N/A
			GM-R4	N/A	2.3	1.03	N/A	N/A	N/A	N/A
			GM-R5	N/A	2.1	1.01	N/A	N/A	N/A	N/A
Unnamed (FN)	1.67	5.6	FN-R1	N/A	1.1	1.02	N/A	N/A	N/A	N/A
Crooked Creek	100.00	335.5	CR-R1	CR0.3	0.2	1.62	C4	gravel/cobble	23.4*	7.1*
			CR-R2	N/A	0.2	1.97	N/A	N/A	N/A	N/A
			CR-R3	CR1	0.1	2.06	C4	gravel/cobble	54.2	16.5
			CR-R3	CR0.7	0.1	2.06	C4	gravel/cobble	49.3	15.0
			CR-R4	N/A	0.1	2.70	N/A	N/A	N/A	N/A
			CR-R5	CR2	0.3	1.65	C4	gravel/cobble	36.0	11.0

Notes:

- 1 Gradient and sinuosity were calculated over the reach of stream flown for the aerial salmon counts. For those streams not flown, slope and sinuosity were calculated for the primary mainstem of the drainage.
- 2 Data on entrenchment, or flood prone width have not been collected for all stream sections; therefore, classifications are only an average estimate based on conditions near sampling reaches.
- 3 Dominant substrate calculations were not conducted at every site or stream and should be considered an estimate based on various field collection sources.
- 4 Average wetted width measured at biomonitoring site. *Wetted width at CR0.3 represents only the side channel in which the survey was conducted; Total wetted width for the entire mainstem at this location is approximately 60ft.

N/A = Not available at this time.

Source: OtterTail 2012b; Rosgen and Silvey 2006.

Dome Creek (DM1) drains an area of 6.8 mi². The Dome Creek monitoring site was established to document aquatic resource conditions within a sub-basin of the Crooked Creek drainage upstream from existing and proposed mining activities. Dome Creek, which flows into Donlin Creek, has a moderate gradient with gravel suitable for salmonid spawning being a dominant substrate in riffle areas (OtterTail 2012b). Only coho and Dolly Varden have been observed in the lower quarter mile of the creek that is passable to fish.

Middle Watershed

Upper Crooked Creek, Quartz Gulch, Snow Gulch, Queen Gulch, Lewis Gulch, American Creek, Omega Gulch, and Anaconda Creek. Upper Crooked Creek, from the confluence of Donlin Creek and Flat Creek downstream to the Crevice Creek confluence (Figure 3.13-1), has a high sinuosity and a repetitive sequence of classic riffle-run-pool habitat types. Gravel and cobble substrates dominate the riffle areas (Table 3.13-1). During winter months, heavy icing may cause variable flows, as some locations may freeze to the stream bottom. The presence of multiple-year classes of slimy sculpin indicate that pool depth and frequency are apparently sufficient for fish overwintering (OtterTail 2012b).

Because the proposed project has the potential to affect the quantity and distribution of surface water flows within the upper Crooked Creek drainage, a habitat mapping study was conducted along 33 miles of Crooked Creek. A key study objective involved the characterization of aquatic habitat by quantifying the distribution and classification of salmonid rearing and spawning areas (Table 3.13-2) at baseflow conditions (OtterTail 2012b). As shown in Table 3.13-3, about 61 percent (568.6 mi²) of the total wetted surface area at baseflow conditions consisted of run habitat. An analysis of the creek's suitability classification with respect to juvenile salmonid habitat indicated that most of the creek's run habitat (64 percent) was characterized as fair quality; 33 percent was considered good quality; and a very small fraction (less than 1 percent) was considered excellent quality. Riffle habitat made up 12 percent (112.7 mi²) of the total wetted surface area surveyed. Most of the riffle habitat (71 percent) was classified as being of poor quality juvenile salmonid habitat, 27 percent was classified as fair quality, and less than 2 percent was classified as good quality. It was noted that many juvenile salmon were observed along shallow margins of the stream within low-velocity riffles (OtterTail 2012b). Pool habitat accounted for approximately 8 percent (70.6 mi²) of the total wetted surface area with 70 percent of the pool habitat characterized as good quality, 25 percent as fair quality, and 5 percent as excellent quality. During higher flow conditions, it is anticipated that most of this pool habitat would likely be classified as run habitat. Glides and fast-run habitat were not very common and were primarily characterized as providing fair salmon rearing habitat (Table 3.13-2 and Table 3.13-3).

Table 3.13-2: Summary of Habitat Type and Attribute Data for Crooked Creek (2009)

Parameter	Habitat Type ¹								Total
	Riffle	Fast Run	Run	Glide	Pool	Side Arm	Back Water	Abandoned Channel	
General Statistics									
Number of Habitats	206	5	325	16	118	39	83	48	840
Total Wetted Surface Area (mi²)	43.52	1.46	219.55	16.77	27.25	10.57	16.43	21.85	357.41
% of Total Wetted Surface Area	12.18	0.41	61.43	4.69	7.63	2.96	4.60	6.11	100
Mean Water Velocity (f/s)	2.01	2.64	1.37	1.52	0.96	0.93	0.86	0.87	1.40
Dominant Substrate (% Area) ²									
Silt, loam, clay (<0.063mm)	--	--	0.32	--	7.31	22.49	67.51	76.35	21.75
Sand (0.063–2mm)	--	--	11.36	--	39.82	10.71	7.94	0.71	8.82
Medium to fine gravel (2mm–2cm)	2.67	--	13.09	16.20	17.19	40.96	0.74	1.29	11.52
Coarse gravel (2–6.3cm)	62.76	42.01	53.18	73.82	30.57	22.89	20.69	6.96	39.11
Small cobble (6.3–20cm)	34.57	57.99	22.05	9.98	5.11	1.94	2.01	--	16.71
Medium cobble (20–40cm)	--	--	--	--	--	--	--	--	--
Large cobble (>40cm)	--	--	--	--	--	--	--	--	--
Bedrock	--	--	--	--	--	--	--	--	--
Organic sludge	--	--	--	--	--	--	0.26	--	0.03
Deposits of particulate organic matter	--	--	--	--	--	--	0.40	0.03	0.05
Submerged plants	--	--	--	--	--	--	0.45	14.65	1.89
Wood	--	--	--	--	--	1.01	--	--	0.13
Abundant Habitat Features (% Occurrence) ³									
Boulders	0.08	--	--	--	--	--	--	1.36	0.18
Overhanging Vegetation	0.07	--	0.43	--	2.13	--	0.51	0.67	0.48
Submerged Vegetation	0.65	--	0.40	--	1.08	0.49	13.82	81.77	12.28
Canopy Shading	2.06	--	12.76	0.47	2.90	38.39	23.83	5.00	10.68
Undercut Bank	19.68	--	28.56	80.26	10.17	8.37	2.40	0.93	18.80
Woody Debris	1.54	--	11.08	--	22.28	36.43	22.55	7.58	12.68

Table 3.13-2: Summary of Habitat Type and Attribute Data for Crooked Creek (2009)

Parameter	Habitat Type ¹								Total
	Riffle	Fast Run	Run	Glide	Pool	Side Arm	Back Water	Abandoned Channel	
Shallow Margin	30.16	--	17.53	9.51	26.76	50.66	87.14	83.23	38.12

Notes:

- 1 For definitions of habitat types and abundant habitat features, refer to (OtterTail 2011).
- 2 Dominant Substrate (% Area) Total provides the average for each type of substrate over all habitat types.
- 3 Abundant Habitat Features (% Occurrence) refers to the percentage of habitat types mapped in which a feature is abundant (>50% area of habitat type). For example, shallow margins were an abundant habitat feature in 30.16% of riffles.

Source: OtterTail 2012b.

Table 3.13-3: Juvenile Salmon Habitat Suitability for Baseflow Conditions
Crooked Creek (2009)

	Area	Suitability Classification ¹				
		Excellent	Good	Fair	Poor	Total
Riffle	mi ²	--	1.74	30.73	80.26	112.73
	%	--	1.54	27.26	71.19	
Fast Run	mi ²	--	--	2.79	1.01	3.79
	%	--	--	73.49	26.51	
Run	mi ²	1.07	189.70	364.90	12.97	568.64
	%	0.19	33.36	64.17	2.28	
Glide	mi ²	--	5.49	37.94	--	43.43
	%	--	12.64	87.36	--	
Pool	mi ²	3.48	49.52	17.58	--	70.59
	%	4.93	70.15	24.91	--	
Side Arm	mi ²	--	9.24	16.67	1.46	27.38
	%	--	33.76	60.90	5.34	
Back Water	mi ²	17.30	24.28	0.97	--	42.55
	%	40.66	57.06	2.28	--	
Abandoned Channel	mi ²	46.65	9.94	--	--	56.59
	%	82.44	17.56	--	--	

Notes:

- 1 Refer to (OtterTail 2011) for definitions of habitat types and suitability classifications. '%' is the percent area within each habitat type that is classified "excellent," "good," "fair," or "poor." Suitability classification included a ranked scoring for a number of factors including habitat type (riffle, pool, backwater, etc.) and channel attributes (boulders, submerged and overhanging vegetation, undercut banks, woody debris, shallow water margins, etc.).

Source: OtterTail 2012e.

Higher redd density in the lower drainage may be explained by the closer proximity to the Kuskokwim River, higher summer and winter flows influenced by the Getmuna and Bell creek drainages, and greater availability of suitable spawning habitat.

Backwaters and abandoned channels (relic meander cutoffs) accounted for only 38.3 mi² or 5 and 6 percent of the total wetted surface area, respectively (Table 3.13-2). Although a relatively small percentage of total habitat, abandoned channel habitat accounted for the largest amount (82 percent) of juvenile coho salmon habitat classified as excellent quality (approximately 47 mi²) (OtterTail 2012b).

Quartz Gulch (site QZ1) is a small, high-gradient drainage with an area of 1.2 mi². This drainage has been extensively mined in its lower end, and some silt from this area continues to be transported into Donlin Creek. Located just downstream of Quartz Gulch, Snow Gulch (sites SN1 and SN2) drains an area of 3.4 mi². The lower end of the Snow Gulch has been extensively mined; sections of the stream have been re-routed, but the stream above the mining area is essentially undisturbed and varies from a deeply incised channel with silt substrates to meandering sections with gravel substrates and beaver activity. Queen Gulch (site QU1) drains an area of 0.7 mi². The lower end of Queen Gulch also has been severely disturbed by placer mining. Characteristics for these streams are included in Table 3.13-1 (OtterTail 2012b).

The American Creek drainage (sites AM1 and AM2) is the proposed location of the mine pit and WRF (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). American Creek drains an area of 6.9 mi², comprising 2 percent of the entire Crooked Creek drainage. Beaver activity is prevalent throughout the drainage; but in reaches unaffected by beavers the stream is a narrow, incised channel with gravel substrates dominating riffle areas (Table 3.13-1). Flowing water is present year-round in upstream portions of American Creek, while the lower reaches may freeze to the bottom in winter resulting in discontinuous surface flow (OtterTail 2012b).

The small watersheds of Lewis Gulch (0.8 mi²) and Omega Gulch (1.0 mi²) have limited aquatic habitat, lack overwintering habitat, and are unlikely to support fish (sites LE1 and OM1, respectively) (OtterTail 2012b).

Anaconda Creek (sites AN1 and AN2) is the proposed location of the TSF (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Silt and sand are the dominant substrates in this creek, which drains an area of 7.9 mi² (Table 3.13-1). Aquatic habitat is classified as poor quality due to the lack of gravel and cobble substrate, a highly incised channel, and highly variable water quality caused by flooding, major stream erosion, turbidity, and silt deposits. A low abundance and diversity of macroinvertebrates and fish were observed in the creek.

Salmon spawning habitat within Crooked Creek is concentrated in the lower sections of the drainage below the Getmuna Creek confluence, although salmon redds (predominately those of coho salmon) also have been observed in the upper Crooked Creek drainage (OtterTail 2012b). Higher redd density in the lower drainage may be explained by the closer proximity to the Kuskokwim River, higher summer and winter flows influenced by the Getmuna and Bell creek drainages, and greater availability of suitable spawning habitat.

Backwaters and abandoned channels (relic meander cutoffs) accounted for only 38.3 mi² or 5 and 6 percent of the total wetted surface area, respectively (Table 3.13-2). Although a relatively small percentage of total habitat, abandoned channel habitat accounted for the largest amount (82 percent) of juvenile coho salmon habitat classified as excellent quality (approximately 47 mi²) (OtterTail 2012b).

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Lower Watershed

Lower Crooked Creek, Crevice Creek, Unnamed (AC) Creek, Unnamed (BC) Creek, Getmuna Creek, and Bell Creek. Lower Crooked Creek between sites CR0.7 and CR0.3 (Crevice Creek confluence downstream to the mouth near the Village of Crooked Creek) has a sinuous stream character with a repetitive sequence of classic riffle-run-pool habitat types (Figure 3.13-1). Compared to Donlin Creek in the upper drainage, this reach receives greater flow and has less gradient, which has resulted in greater channel sinuosity. Substrates are dominated by gravel and cobbles in riffle areas and silt/sand in slow-water areas. Surface flows in lower Crooked Creek are likely adequate to support overwintering fish at most locations. The presence of multiple-year classes of slimy sculpin indicate the frequency and depth of pools are likely to provide adequate overwintering conditions for fish (OtterTail 2012b).

Crevice Creek (site CV1) drains an area of 6.8 mi² and has little sinuosity. The channel is covered with many overhanging trees and has a narrow, incised, and highly variable character with very little pool habitat. Substrate is dominated by gravel in riffle areas (Table 3.13-1), providing good habitat for macroinvertebrate populations. Sand and silt substrates are common in pool habitats (OtterTail 2012b).

Eagle Creek drains an area of 8.7 mi² and enters Crooked Creek from the west, just downstream from Crevice Creek (site EG1). The permanent accommodations camp would be located in the

upper slopes of this drainage (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). Similar to Anaconda Creek, the channel is highly incised and the substrate is dominated by silt and sand (Table 3.13-1) (OtterTail 2012b).

Two small unnamed drainages, (sites AC1 and BC1), drain areas of approximately 0.3 mi² and 0.4 mi², respectively, and enter Crooked Creek from the east, downstream of Crevice Creek (Figure 3.13-1). Both streams have silt- and sand-dominated substrates and limited aquatic habitat. These streams are located near the site of a potential material source of rock and aggregate for proposed construction activities (OtterTail 2012b).

Getmuna Creek drains an area of 98.6 mi² and is the largest tributary in the Crooked Creek system. A proposed material borrow site would be located in the upper drainage near the crossing of the proposed mine access road (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). The creek (site GM1) has a repetitive sequence of riffle-run-pool habitat types with less sinuosity than lower Crooked Creek due to its steeper gradient and different geomorphology. The water clarity of Getmuna Creek has been consistently higher than in the mainstem of Crooked Creek due to the geological character of its watershed (OtterTail 2012b). The lower reaches of Getmuna Creek have sand, gravel, and cobble substrate, and good pool habitat. The upper reaches of Getmuna Creek contain numerous riffles with gravel and cobble substrate. Large woody debris and off-channel habitats are abundant throughout the drainage (OtterTail 2012b).

Bell Creek (site BL1) is the second largest drainage in the Crooked Creek watershed covering 71.3 mi². This drainage joins Crooked Creek from the east, downstream from the confluence of Getmuna Creek. Stream conditions include gravel and cobble substrates, low-to-moderate gradient, and relatively high sinuosity resulting in classic riffle-run-pool habitat types (OtterTail 2012b). Bell Creek is included here because it is an important component of the Crooked Creek watershed, even though the Bell Creek drainage is not expected to be affected by the Donlin Gold Project.

3.13.2.1.2 FISH

All activities that would occur within the proposed mine site area are located within the Crooked Creek drainage where fish studies related to the proposed project have been conducted since 1996 (OtterTail 2012b). A formal aquatic biomonitoring program was initiated in 2004 by OtterTail Environmental, Inc. The biomonitoring program included electrofishing, fish trapping, macroinvertebrate collections, fish tissue metals analysis, and aerial adult salmon surveys. In 2008, a resistance-board fish weir was installed on Crooked Creek to estimate adult salmon escapement. Additionally, an intensive stream habitat survey was conducted in 2009 to document aquatic habitat throughout the Crooked Creek mainstem.

Fish population assessments within the Crooked Creek drainage have shown that this system supports viable populations of Chinook, chum, and coho salmon. Since the installation of the fish weir in 2008, limited numbers of sockeye and pink salmon also have been documented. With the exception of Donlin, Bell, and Getmuna tributaries, Chinook or chum salmon have not been documented in other Crooked Creek tributaries. However, limited numbers of coho salmon have been reported in several tributaries. Many other resident fish species typical of the Kuskokwim River drainage also have been found throughout the mine site area (Table 3.13-4).

More detailed descriptions of fish communities in streams surveyed within the mine site area are provided below.

Upper Watershed

Donlin Creek, Flat Creek, and Dome Creek. Donlin Creek (DO1) provides habitat that supports populations of slimy sculpin, Dolly Varden, burbot, Arctic grayling, and juvenile and adult coho salmon (Table 3.13-4 and Table 3.13-5). Neither juvenile nor adult Chinook salmon have been observed in Donlin Creek during surveys. Coho salmon young-of-the-year have been observed every year, suggesting that the upper reaches of Donlin Creek are likely used by coho salmon for spawning and rearing. Overall, slimy sculpin and coho salmon juveniles appear to be the most abundant species in the upper reaches of this stream while Dolly Varden, Arctic grayling, and burbot were fairly common. The round whitefish was recently documented at this site for the first time (OtterTail 2012b). Intense beaver activity exists in Donlin Creek, often limiting upstream fish migration during dry years (OtterTail 2012b).

Flat Creek (FL1) supports coho salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, and burbot (Table 3.13-5). Slimy sculpin consistently has been the dominant species in this stream. Coho salmon appear to use Flat Creek for rearing of young in very limited numbers, and some spawning by adults. The only adult coho salmon observed at this site, however, was reported during an aerial survey (Table 3.13-6). Chinook or chum salmon, of any life stage, have not been observed in this creek (Table 3.13-5 and Table 3.13-6).

Species composition at Flat and Donlin creeks is very similar, but substantially more juvenile and adult coho salmon have been observed at Donlin Creek. Young-of-the year coho (total length less than 55 mm) have been observed consistently in both creeks, indicating that spawning and rearing could occur in these drainages.

Surveys of Dome Creek have documented populations of juvenile coho salmon and Dolly Varden (Table 3.13-5). A limited number of adult coho salmon also have been observed in lower reaches of Dome Creek during aerial surveys (Table 3.13-6).

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Table 3.13-4: Fish Species Identified within the Crooked Creek Drainage (2004–2011)

Fish Species			Drainage																			
Family	Scientific Name	Common Name	Donlin Creek ¹	Flat Creek	Dome Creek	Quartz Gulch	Snow Gulch	Queen Gulch	Crooked Creek ²	Lewis Gulch	American Creek	Grouse Creek	Omega Gulch	Anaconda Creek	Crevice Creek	Eagle Creek	Unnamed (BC)	Unnamed (AC)	Getmuna Creek	Unnamed (FN)	Bell Creek	Grand Total
Salmonidae	<i>Oncorhynchus tshawytscha</i>	Chinook salmon							X										X		X	X
	<i>O. keta</i>	Chum salmon	X						X										X		X	X
	<i>O.kisutch</i>	Coho salmon	X	X	X		X ³		X		X	X		X ⁵					X	X	X	X
	<i>O.gorbuscha</i>	Pink salmon							X ⁴													X
	<i>O.nerka</i>	Sockeye salmon							X										X			X
	<i>O.mykiss</i>	Rainbow trout							X ⁴													X
	<i>Salvelinus malma</i>	Dolly Varden	X	X	X		X		X		X	X		X	X	X	X		X		X	X
	<i>Thymallus arcticus</i>	Arctic grayling	X	X					X		X								X		X	X
	<i>Prosopium cylindraceum</i>	Round whitefish	X	X					X										X		X	X
	<i>Coregonus pidschian</i>	Humpback whitefish							X ⁴													X
Catostomidae	<i>Catostomus catostomus</i>	Longnose sucker							X													X
Cottidae	<i>Cottus cognatus</i>	Slimy sculpin	X	X					X		X	X		X	X	X			X		X	X
Esocidae	<i>Esox Lucius</i>	Northern pike							X													X
Umbridae	<i>Dallia pectoralis</i>	Alaska blackfish							X													X
Petromyzontidae	<i>Lethenteron alaskense</i>	Alaskan brook lamprey							X													X
Gadidae	<i>Lota lota</i>	Burbot	X	X					X		X	X		X		X						X
Gasterosteidae	<i>Pungittius pungittius</i>	Ninespine stickleback							X												X	X
Total Species Count			7	6	2	0	2	0	17	0	5	4	0	4	2	3	1	0	8	1	8	17

Notes:

Table includes data from trapping, all electrofishing passes, aerial surveys, and weir counts.

1 Mouth to endpoint of survey approximately 3 miles (4.8 km) upstream from confluence with Ophir Creek.

2 Mouth to terminus at confluence of Flat and Donlin creeks.

3 Coho salmon adults have only been found in the lower reach of Snow Gulch.

4 Observed at weir site only.

5 A coho salmon juvenile was collected downstream of AN1. One adult coho salmon observed to date. ADF&G also documented coho salmon juveniles downstream of AN1.

Source: ADF&G 2010; OtterTail 2012b.

Table 3.13-5: Summary of Electrofishing Results within the Crooked Creek Drainage (2004–2011)

Stream Name	Site	# Years	# Species	Average # Fish Captured (#/300 feet [91 m]) ¹																									
				Coho salmon (juvenile)		Chinook salmon (juvenile)		Sockeye salmon (juvenile)		Dolly Varden		Arctic grayling		Round whitefish		Longnose sucker		Slimy sculpin		Alaska blackfish		Alaskan brook lamprey		Burbot		Ninespine stickleback		Total	
				Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	SD±
Donlin Creek	DO1	7	6	45.9	2 - 182		--		--	3.8	0 - 6.9	2.6	0 - 6.9	0.2	0 - 1		--	94.3	18.7 - 167.1		--		--	1.8	0 - 3		--	148.7	120.1
Flat Creek	FL1	6	6	1.6	0 - 3.1		--		--	2.1	0 - 10.9	1.0	0 - 3.1	0.3	0 - 1.5		--	129.0	55.8 - 225.4		--		--	2.8	0 - 6.2		--	136.7	65.1
Dome Creek	DM1	2	2	28.0	0 - 56.1		--		--	26.8	22 - 31.7		--		--		--		--		--		--		--		--	54.9	46.6
Quartz Gulch	QZ1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	0.0	0.0
Snow Gulch	SN1	1	1		--		--		--	10.8	N/A		--		--		--		--		--		--		--		--	10.8	N/A
Snow Gulch	SN2	4	1		--		--		--	3.4	1.2 - 9.4		--		--		--		--		--		--		--		--	3.4	3.7
Queen Gulch	QU1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	0.0	N/A
Crooked Creek	CR2	7	7	22.8	3 - 70.1	3.0	0 - 7.6		--	5.1	1.5 - 11.8	6.1	0 - 27.6	1.6	0 - 7.9		--	155.1	99.1 - 274.3	0.3	0 - 2		--	1.0	0 - 3.9		--	195.1	125.5
	CR1	7	8	115.0	1.6 - 831.6	2.7	0 - 10.9		--	0.4	0 - 1.6	6.7	0 - 29.5	0.8	0 - 3.1		--	337.8	228.5 - 430.6		--		--	1.8	0 - 4.7	2.1	0 - 3.1	467.3	420.2
	CR0.7	5	10	47.7	6.4 - 195.7	3.7	0 - 8.5	4.3	0 - 23.4	5.0	0 - 8.5	13.8	0 - 36.2	2.1	0 - 6.4	0.5	0 - 2.1	355.0	208.5 - 704.3	0.4	0 - 2.1		--	6.4	2.1 - 12.8		--	438.9	320.4
	CR0.3	5	10	11.8	1.5 - 45.5	6.8	0 - 22.7		--	3.0	0 - 12.1	40.3	10.6 - 71.2	5.8	0 - 12.1	7.0	1.5 - 15.2	242.1	121.2 - 319.7	0.4	0 - 1.5	3.4	1.5 - 6.1	5.3	1.5 - 7.6		--	325.9	153.8
Lewis Gulch	LE1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	0.0	N/A
American Creek	AM1	6	5	7.0	0 - 18.3		--		--	8.2	2.7 - 15.5	0.5	0 - 1.8		--		--	41.0	3.7 - 99.7		--		--	0.3	0 - 0.9		--	57.0	58.3
	AM2	1	1		--		--		--	57.0	N/A		--		--		--		--		--		--		--		--	57.0	N/A
Grouse Creek	GR1	1	2		--		--		--	1.4	N/A		--		--		--	36.2	N/A		--		--		--		--	37.7	N/A
Omega Gulch	OM1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	0.0	N/A
Anaconda Creek	AN1	6	3	**	0 - 1		--		--	1.0	0 - 3	0.9	0 - 6		--		--	10.8	0.9 - 18		--		--	1.0	0 - 2.7		--	13.7	9.3
	AN2	4	1		--		--		--	3.4	2 - 3.9		--		--		--		--		--		--		--		--	3.4	1.0
Crevice Creek	CV1	4	2		--		--		--	0.6	0 - 2.2		--		--		--	42.0	2.2 - 134.3		--		--		--		--	42.5	63.7
Eagle Creek	EG1	1	3		--		--		--	0.9	N/A		--		--		--	11.8	N/A		--		--	0.9	N/A		--	13.6	N/A
Unnamed	BC1	1	1		--		--		--	1.0	N/A		--		--		--		--		--		--		--		--	1.0	N/A
Unnamed	AC1	1	0		--		--		--		--		--		--		--		--		--		--		--		--	0.0	N/A
Getmuna Creek	GM1	3	7	90.8	15.6 - 231.6	12.0	6 - 21.6	0.6	0 - 2.4	2.4	0 - 7.2	1.2	0 - 2.4	0.4	0 - 1.2		--	410.8	175.2 - 536.4		--		--		--		--	518.2	341.9
Bell Creek	BL1	1	8	4.0	N/A	1.0	N/A		--	3.0	N/A	5.0	N/A	3.0	N/A		--	154.0	N/A		--		--		--	2.0	N/A	172.0	N/A
Totals			12*	374.8		29.2		4.9		139.4		78.1		14.2		7.5		2,020.0		1.1		3.4		21.3		4.1		2,697.9	1,729.3

Notes:
See Figure 3.13-1 for site locations.
1 #/300 feet = number of fish per 300 feet (91 m). Fish counts presented in this table represent minimum populations because electrofishing was limited to one pass per reach in 2005 & 2006. To maintain consistent comparisons, only one-pass data were used for all years.
* A total of 17 species have been found in Crooked Creek - Northern pike, chum salmon, pink salmon, humpback whitefish and rainbow trout were documented using other methods including aerial surveys and weir video. Any adult salmon observed in electrofishing reaches were allowed to pass or avoided and are not included in the above counts.
SD = standard deviation over n (years) N/A = Standard deviation and ranges not calculated for sites with only 1 year of data.
** A coho salmon juvenile was collected in 2011 downstream of AN1 in optimum habitat. One adult coho salmon observed to date. ADF&G also documented coho salmon juveniles downstream of AN1.
Source: ADF&G 2010; OtterTail 2012b.

Table 3.13-6: Averaged Adult Salmon Aerial Counts for the Crooked Creek Drainage (2004–2010)

Crooked Creek Drainage	REACH	# of Years Surveyed (Summer, Fall)	Coho			Chinook			Chum			Sockeye			Mean Total Salmon	Mean % Salmon
			Mean ¹	Min	Max	Mean ¹	Min	Max	Mean ¹	Min	Max	Mean ¹	Min	Max		
Reference Streams	DO-R3	7,8	47.9	0	208	0.0	0	0	0.0	0	0	0.0	0	0	47.9	3.4
	DO-R2	8,8	53.3	1	190	0.0	0	0	0.8	0	4	0.0	0	0	54.0	3.8
	DO-R1	8,8	26.9	0	58	0.0	0	0	1.1	0	7	0.0	0	0	28.0	2.0
	FL-R1	6,8	0.1	0	1	0.0	0	0	0.0	0	0	0.0	0	0	0.1	0.0
Donlin Creek Tributaries	DM-R1	1,4	1.5	0	5	0.0	0	0	0.0	0	0	0.0	0	0	1.5	0.1
	SN-R1	3,8	0.4	0	2	0.0	0	0	0.0	0	0	0.0	0	0	0.4	0.0
Crooked Creek Mainstem	CR-R5	8,8	16.8	0	39	0.8	0	6	2.1	0	8	0.0	0	0	19.6	1.4
	CR-R4	8,8	14.0	0	38	1.1	0	3	5.6	0	17	0.0	0	0	20.8	1.5
	CR-R3	8,8	10.0	0	25	1.1	0	4	7.6	1	24	0.0	0	0	18.8	1.3
	CR-R2	8,8	13.6	0	40	5.3	0	20	107.9	30	178	0.0	0	0	126.8	9.0
	CR-R1	8,8	4.3	0	14	6.4	0	29	157.3	16	291	0.4	0	3	168.3	12.0
Crooked Creek Tributaries	AM-R1	5,7	0.4	0	3	0.0	0	0	0.0	0	0	0.0	0	0	0.4	0.0
	GR-R1	1,2	1.0	0	2	0.0	0	0	0.0	0	0	0.0	0	0	1.0	0.1
	AN-R1	5,7	0.1	0	1	0.0	0	0	0.0	0	0	0.0	0	0	0.1	0.0
	CV-R1	5,7	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0.0
	EG-R1	3,3	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0.0
Bell Creek Mainstem	BL-R1	1,1	134.0	134	134	0.0	0	0	7.0	7	7	0.0	0	0	141.0	10.0
Bell Creek	BL-R3	1,1	97.0	97	97	0.0	0	0	0.0	0	0	0.0	0	0	97.0	6.9

Table 3.13-6: Averaged Adult Salmon Aerial Counts for the Crooked Creek Drainage (2004–2010)

Crooked Creek Drainage	REACH	# of Years Surveyed (Summer, Fall)	Coho			Chinook			Chum			Sockeye			Mean Total Salmon	Mean % Salmon
			Mean ¹	Min	Max	Mean ¹	Min	Max	Mean ¹	Min	Max	Mean ¹	Min	Max		
Tributaries	BL-R2	1,1	122.0	122	122	0.0	0	0	0.0	0	0	0.0	0	0	122.0	8.7
Getmuna Creek Mainstem	GM-R1	5,6	78.7	3	156	20.2	3	44	286.8	28	701	1.8	0	4	387.5	27.6
Getmuna Creek Tributaries	GM-R5	1,1	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0.0
	GM-R4	2,3	30.7	12	57	0.0	0	0	1.5	0	3	0.0	0	0	32.2	2.3
	GM-R3	5,5	42.0	30	60	3.4	0	11	18.0	4	50	0.0	0	0	63.4	4.5
	GM-R2	5,5	46.2	10	105	0.8	0	4	24.8	0	113	0.0	0	0	71.8	5.1
	FN-R1	0,1	2.0	2	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	2.0	0.1
Crooked Creek Drainage Total			742.7	3	1,064	39.0	5	62	620.5	82	1,223	2.2	0	7	1,404.4	
Species RA(%) ²			52.9%			2.8%			44.2%			0.2%				

Notes:

1 Mean = total # fish observed / # years surveyed.

2 Species RA= percent relative abundance of each species. Refer to Figure 3.13-1 for aerial reach locations and adult salmon distributions within the Crooked Creek drainage.

* Only completed fall coho surveys for GM-R1 and DO-R3 in the fall of 2006.

Source: OtterTail 2012b.

Middle Watershed

Upper Crooked Creek, Quartz Gulch, Snow Gulch, Queen Gulch, American Creek, Lewis Gulch, Omega Gulch, and Anaconda Creek. Electrofishing surveys in Crooked Creek indicate this stream provides habitat to juvenile coho and Chinook salmon, Dolly Varden, Arctic grayling, round whitefish, slimy sculpin, burbot, and ninespine stickleback (Table 3.13-5). Of these, slimy sculpin has been consistently the most abundant species, followed by juvenile coho salmon. The presence of juvenile Arctic grayling in Upper Crooked Creek sites suggest nearby spawning of adult Arctic grayling. The presence of juvenile Dolly Varden at these sites is inconclusive, suggesting either that they may overwinter this far upstream in the drainage or simply be seasonally dispersing to utilize these habitats during the open-water months. Aerial surveys along upper reaches of Crooked Creek (reaches CR-R4 and CR-R5) also have documented adult Chinook, chum, and coho salmon in lower numbers than in lower reaches (Table 3.13-6 and Figure 3.13-1). Although aerial surveys and field observations documented limited numbers of chum salmon spawning upstream from this reach in Donlin Creek (reach DO-R1), no juveniles were observed during electrofishing surveys possibly because their fry migrate downstream soon after emergence from spawning gravels.

Quartz Gulch and Queen Gulch are two small streams influenced by historic or current placer mining activity. Electrofishing surveys have not documented fish in either stream (Table 3.13-5).

Electrofishing surveys at Snow Gulch (SN1 and SN2) suggest that Dolly Varden is the only fish species that occurs in this stream (Table 3.13-5). All Dolly Varden collected were over 80 mm in total length. Previous aerial spawning surveys documented coho salmon in the lower Snow Gulch reach (reach SN-R1, Table 3.13-6). Fish habitat in Snow Gulch is limited due to the small size of the drainage. In addition, placer mining activities have filled and blocked the stream channel causing obstructions that could prevent coho salmon and other resident species from entering the main channel of this stream. Survey site SN2 is located well above current placer mining activities (Figure 3.13-1).

The American Creek drainage is the proposed location of the WRF and mine pit (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Species found during electrofishing surveys (sites AM1 and AM2) include juvenile coho salmon, Dolly Varden, Arctic grayling, slimy sculpin, and a limited number of burbot (Table 3.13-5). The presence of coho salmon juveniles at site AM1 suggests that limited spawning may occur in or near this drainage. Aerial surveys conducted along American Creek also have documented the presence of adult coho salmon in small numbers, while Chinook and chum salmon have not been observed (Table 3.13-6). A winter-use survey determined that surface flow was discontinuous within American Creek during this season, so overwintering fish distribution may be limited to localized unfrozen areas (NES and HDR Alaska, Inc. 1999). Overall, the potential of American Creek to support coho salmon is likely limited by its small size.

Lewis and Omega Gulches are two other streams that would be directly affected by the proposed mine site, although no fish have been collected during surveys conducted at these locations (Table 3.13-4) (OtterTail 2012b). In addition, Lewis Gulch has been re-routed by placer mine activities and the lowermost reach has been converted to a man-made canal that diverts water into Crooked Creek just upstream of American Creek at site CR2 (Figure 3.13-1).

Anaconda Creek is the proposed location of the tailings storage facility (TSF) (Figure 3.13-1, and Figure 2.3-1 in Chapter 2, Alternatives). Suitable spawning habitat for salmon species is unlikely

to occur in this creek since the dominant substrate type consists of silt. Electrofishing surveys in sites along this creek (AN1 and AN2) have only documented Dolly Varden, slimy sculpin, and burbot in low abundance (Table 3.13-5). Juvenile coho salmon have been observed downstream of site AN1 (ADF&G 2010; OtterTail 2012b). The single adult coho salmon observed during aerial surveys in the lowermost reach of Anaconda Creek, however, was likely to be a stray from a nearby tributary or the Crooked Creek mainstem (Table 3.13-6) (OtterTail 2012b).

Lower Watershed

Lower Crooked Creek, Crevice Creek, Unnamed (AC) Creek, Unnamed (BC) Creek, Getmuna Creek, and Bell Creek. Electrofishing surveys conducted along the lower reaches of Crooked Creek (CR0.7 and CR0.3) have revealed the presence of Arctic grayling, Dolly Varden, round whitefish, longnose sucker, slimy sculpin, Alaska blackfish, Alaskan brook lamprey, as well as juvenile coho, chum, and sockeye salmon (Table 3.13-5). The abundance of juvenile coho salmon observed at these sites was generally lower than at the sites surveyed upstream in Crooked Creek (CR1 and CR2). Conversely, a larger number of adult Chinook, chum, and coho salmon were observed during aerial surveys at the lowermost reaches (CR-R1, CR-R2 and CR-R3) than in reaches located farther upstream (Table 3.13-6). The majority of Chinook salmon and chum salmon spawning was observed to occur in reaches CR-R1 and CR-R2 (Figure 3.13-1). As noted previously, Chinook salmon have been observed as far upstream as the upper Crooked Creek mainstem (reach CR-R5) but have not been observed in Donlin Creek or any of the upper tributaries surveyed (Table 3.13-6). A small number of adult chum salmon have been sporadically observed as far upstream as Donlin Creek (OtterTail 2012b).

In addition to fish population data based on electrofishing and aerial surveys in Crooked Creek, underwater video from the resistance-board weir installed in 2008 at lower Crooked Creek 1.5 river miles upstream from the Kuskokwim River confluence has provided more insight into salmon escapement in this drainage (Table 3.13-7). The weir is located downstream of all major tributaries, allowing for an accurate portrayal of escapement totals for the entire drainage (Figure 3.13-1) (OtterTail 2012b). Coho salmon escapement has ranged from a low of 591 in 2011 to a high of 3,828 in 2008. Half of the run has generally passed through the weir by early September. The Chinook salmon run is small, ranging from 23 to 100 fish between 2008 and 2011, with median passage occurring in mid-July. Chum salmon numbers have ranged from 1,257 to 1,991 during these same years, with half of the run generally passing by the end of July. Small numbers of pink salmon have been documented at the weir with 59 fish documented in 2009. Sockeye salmon, the least abundant salmon in Crooked Creek, have median passage dates that extend from mid-July to early August, similar to pink salmon. Sockeye salmon numbers ranged from 5 to 10 fish between 2009 and 2011. Other fish species documented by weir video in Crooked Creek include humpback whitefish, northern pike, and rainbow trout (OtterTail 2012b).

Table 3.13-7: Crooked Creek Weir Salmon Escapement Summary, 2008 to 2011

Species	2008	2009		2010		2011	
	#	#	%	#	%	#	%
Chinook Salmon		100	2.89	49	1.94	23	0.93
Chum Salmon		1,991	57.62	1,257	49.72	1,839	74.67
Coho Salmon	3,828	1,295	37.48	1,212	47.94	591	24.0
Pink Salmon		59	1.71	5	0.20	4	0.16
Sockeye Salmon		10	0.29	5	0.20	6	0.24
Totals		3,455		2,528		2,463	

Notes:

Salmon species counts for 2008 were limited to coho salmon given the timing of the weir (located at RM 1.5) becoming operational. It is believed the entirety of this run was counted in 2008. Partial counts for 2008 (i.e., some of the run missed) include 13 Chinook, 665 chum, 8 pink, and 18 sockeye salmon. Weir operational from 7/28/2008 to 9/29/2008, from 6/3/2009 to 9/29/2009, from 6/17/2010 to 9/27/2010, and from 6/27/2011 to 9/27/2011. Weir counts for 2011 are likely underestimated, as the weir was overtopped by high flow from 8/3/2011 to 8/26/2011.

Source: OtterTail 2012b.

The Crevise Creek drainage may be affected by flow diversions associated with the tailings storage facility (TSF). Electrofishing and aerial surveys conducted along this stream at site CV1 and reach CV-R1 have shown that fish diversity is low with only two species observed (i.e., Dolly Varden and slimy sculpin; Table 3.13-5). No salmon species have been observed in Crevise Creek (OtterTail 2012b).

The small unnamed drainages (AC1 and BC1) have not been found to support any salmon species. A single Dolly Varden was observed at site BC1 in 2010 (Table 3.13-5) (OtterTail 2012b).

The upper reaches of Getmuna Creek have been identified as a probable borrow material site for the proposed project (Figure 3.13-1, and Figure 2.3-12 in Chapter 2, Alternatives). The fish community composition in Getmuna Creek is similar to that observed at Lower Crooked Creek sites, but in higher abundance, suggesting it is an important tributary. Juvenile coho, Chinook, and sockeye salmon, as well as Dolly Varden, Arctic grayling, round whitefish, and slimy sculpin have been observed during electrofishing surveys in this creek at sites GM1 and GM3 (Table 3.13-5). Aerial observations also have found relatively high numbers of Chinook, chum, and coho salmon, and low numbers of sockeye salmon in this tributary (Table 3.13-6).

Bell Creek was sampled for the first time in 2011 to help complete the understanding of fish in the Crooked Creek watershed. Electrofishing surveys documented coho salmon, Chinook salmon, round whitefish, Dolly Varden, Arctic grayling, ninespine stickleback, and slimy sculpin. During summer aerial surveys, adult chum salmon were observed in the lower portions of the mainstem in 2011. Fall aerial flights in 2011 documented a substantial adult coho population in Bell Creek (Table 3.13-6).

3.13.2.1.3 ESSENTIAL FISH HABITAT

Under the Magnuson-Stevens Act, EFH is designated for fish species managed by federal Fishery Management Plans. EFH is defined as "those waters and substrates necessary to fish for

spawning, breeding, feeding, or growth to maturity” (16 U.S.C. 1801-1883). EFH involves any of the habitat types utilized by federally-regulated species over their entire life cycle. The Kuskokwim River and certain reaches of many of its tributaries, including those in the Crooked Creek watershed, are classified as EFH for Pacific salmon. This is based on documented uses of these waters and their gravel substrates by various salmon life stages as described in state-wide inventories by NMFS and ADF&G (NMFS 2005a; Johnson and Daigneault 2013). Salmon species observed in the Crooked Creek watershed, including drainages associated with the mine site area, include Chinook, chum, coho, pink, and sockeye. Of these, coho, Chinook, and chum salmon are the species having the greatest presence in the Crooked Creek watershed. Spawning and rearing EFH that supports these species occurs in drainages throughout the system (Johnson and Daigneault 2013).

All freshwater resources that these species rely on in the Crooked Creek and Kuskokwim River watersheds over their life cycles are regulated as EFH. Figure 3.13-1 shows drainages within the Crooked Creek watershed and mine site area known to support salmon species associated with EFH.

The NMFS’ Habitat Conservation Division works in coordination with industries, stakeholder groups, government agencies, and private citizens to avoid, minimize, or offset the adverse effects of human activities on EFH and living marine resources in Alaska. This work includes conducting and/or reviewing environmental analyses for a large variety of activities ranging from commercial fishing to coastal development to large transportation and energy projects. The Habitat Conservation Division identifies technically and economically feasible alternatives and offers realistic recommendations for the conservation of valuable living marine resources. The Habitat Conservation Division focuses on activities in habitats used by federally managed fish species located offshore, nearshore, in estuaries, and in freshwater areas important to anadromous salmon (NMFS 2015). Appendix Q, the Draft Essential Fish Habitat Assessment, provides more detailed information on EFH in the project area including an assessment of potential effects of Alternative 2 on these resources.

3.13.2.1.4 MACROINVERTEBRATES

Macroinvertebrates are an important food base for salmonids and effective indicators of water quality and habitat impairment that could result from elevated concentrations of metals and other contaminants and excessive sedimentation. The varied life histories and contaminant tolerances of indicator species can be used to identify both short- and long-term environmental changes, and to establish a relative index of water quality. Benthic macroinvertebrate production in the Lower Kuskokwim River drainage is relatively low, resulting from high sediment loads and sandy substrates. An early study found that annelids were the most dominant invertebrates, followed by mollusks and insects, which were found infrequently (AGRA 1999).

Specific inventories within the mine site area have been conducted for the proposed project to characterize macroinvertebrate communities and to provide baseline data for the assessment of potential impacts from mining (OtterTail 2012b). Although macroinvertebrate communities in Crooked Creek and its tributaries are generally composed of taxa that indicate relatively good water quality, the Shannon diversity, evenness, and Hilsenhoff biotic indices suggest that natural stressors are present in the system (Table 3.13-8). A plausible explanation for this discrepancy is based on the drastic seasonal changes in habitat conditions often observed in

streams in this area. Within the Crooked Creek drainage, several of the smaller tributaries can freeze to the stream bottom during winter (NES and HDR Alaska, Inc. 1999). In addition, the underlying geology of the area causes siltation in the Crooked Creek drainage, which leads to a highly embedded stream bottom. Heavy silt loads fill the interstitial spaces in the gravel, which limits the available habitat for macroinvertebrates (Waters 1995), and exacerbates the effects of winter freezing by limiting the amount of habitat available for colonization.

3.13.2.1.5 FISH TISSUE METALS ANALYSIS

Elevated concentrations of metals in sediments, fish, and other aquatic biota have been documented in the Kuskokwim drainage reflecting the geologic character and historic mining activities of the watershed. The middle Kuskokwim River basin, which includes the Crooked Creek drainage, runs through a highly mineralized region of Alaska's "mercury belt" named for the abundance of mercury mineral deposits and mines in the watershed (Gray et al. 1994, 2000). The potential for mercury, arsenic, antimony, and other trace elements to transfer from mined and unmined sources to the environment, including aquatic habitats, fish, and their prey species, have been extensively studied. Natural sources of mercury include atmospheric transport and deposition from forest fires and volcanoes as well as weathering of mercury-rich mineral deposits (cinnabar and elemental mercury). Human-caused mercury sources include global air pollution (e.g., burning fossil fuels and garbage), historic use of mercury as an amalgam in placer mining, and surface water runoff and groundwater that becomes contaminated when flowing through mine tailings and waste rock (Matz 2012, 2014).

Because of global human health concerns regarding mercury concentrations in fish, contaminant studies in western Alaska have been conducted over the past two decades to assess human health risks from consumption of fish, a primary component of the subsistence diet of Alaska Natives. Such studies have shown measurable concentrations of mercury in predatory fish species in both the Kuskokwim and Yukon river basins (Jewett and Duffy 2007; Matz 2012).

In freshwater aquatic ecosystems, elemental and inorganic mercury complexes can be transformed by anaerobic bacteria to methyl mercury (MeHg), the most toxic form of mercury to humans, in sediments associated with standing water such as wetlands, ponds, lakes, backwaters of rivers and streams, and water storage reservoirs (Fenchel and Blackburn 1979; Manahan 1991; Friberg and Vostal 1972; Matz 2014). Shallow sediment catchments and the anoxic bottom waters of stratified lakes are considered important zones of net methylation which are less prevalent in environments with higher flow and low hydraulic retention (St. Louis et al. 1994). In-river methylation is typically a negligible component of the methylmercury budget for creeks whereas wetlands are frequently the most important contributor of methylmercury to downstream aquatic ecosystems (St. Louis et al. 1996, Berndt and Bavin 2012).

Most mercury in edible fish muscle tissue exists as MeHg which has been found to accumulate in high concentrations in fish-eating, long-lived resident fish such as northern pike and burbot (Jewett and Duffy 2007; Matz 2012). While exceptionally low levels of MeHg have been found in muscle tissue of Pacific salmon, the most commonly consumed fish group in the Alaska subsistence diet, there has been an increased reliance in recent years on non-salmonid species (including northern pike and burbot) in the Kuskokwim River subsistence fishery as Chinook salmon runs have diminished.

Since 2010, the BLM, in cooperation with the FWS and ADF&G, investigated mercury, arsenic, and antimony concentrations in tissue samples of fish collected from the Central Kuskokwim River area. Species sampled included aquatic insects and resident fish (slimy sculpin, juvenile Dolly Varden, and juvenile Arctic grayling) from the mainstem river and tributaries (Red Devil Creek and Cinnabar Creek) associated with abandoned mines whose confluences are located upstream from the Crooked Creek confluence. Other resident fish species, including Arctic grayling, northern pike, sheefish, and burbot, from large tributaries also were collected and sampled. For slimy sculpin, for example, tissue concentrations were higher than levels detected for this species in the Crooked Creek drainage as described below. Section 3.13.2.2.4 provides additional information on metals concentrations in fish in the mainstem Kuskokwim River and its tributaries.

In 2004, an analysis was initiated within the Crooked Creek drainage to assess metals concentrations in the tissue of slimy sculpin, a resident fish species. The two goals of the sampling and analysis plan were to document baseline metals concentrations in the tissue of slimy sculpin of a comparable size (less than 55 mm in length) and to assess the use of sculpin as an indicator species to detect potential future impacts associated with the proposed project (OtterTail 2012b).

A consistent pattern of increasing or decreasing tissue metal concentrations in sculpin across years or sites has not been observed. Metals concentrations, while not significantly different, were generally lower in 2009 than in previous years. In 2010, it was noted that concentrations for certain metals increased to levels observed in years prior to 2009 (Table 3.13-9).

Across all sites surveyed, arsenic, copper, mercury, selenium, and zinc tended to have the smallest coefficients of variation. Therefore, future modifications in the tissue concentration of these metals may be more easily detected than for other metals. A substantial amount of annual variability in concentrations has been observed for all metals except manganese and selenium. Differences in metal concentrations have also been observed across sites. Higher concentrations of both mercury and arsenic have been observed in samples collected at the upper Crooked Creek site (CR2) than in samples from other sites (Table 3.13-9).

Section 3.7.2.1.1, Water Quality, presents additional information regarding total mercury levels in surface waters in the vicinity of the mine site relative to EPA acute and chronic water quality criteria for aquatic life: 2,400 nanograms per liter (ng/L) and 12 ng/L, respectively (EPA 2013k). Based on 465 water samples collected in the Crooked Creek drainage between June 2005 and June 2013, total mercury concentrations ranged from 0.518 to 260 ng/L; mean = 8.2 ng/L (Enos 2013b). These data suggest that existing concentrations of total mercury in surface water are sometimes elevated above the applicable chronic criterion for the protection of aquatic life at locations throughout the mine site area. Ongoing and future mining activities in the Crooked Creek drainage would contribute to additional inputs of mercury to surface water from atmospheric and aqueous sources, possibly causing exceedances of the 12 ng/L chronic criterion at sites within the drainage.

Table 3.13-8: Macroinvertebrate Bioassessment Summary Statistics within the Crooked Creek Drainage (2004 to 2011)

Site		DO1	FL1	DM1	QZ1	SN2	QU1	CR2	CR1	CR0.7	CR0.3	AM1	AM2	GR1	OM1	AN1	AN2	CV1	EG1	GM1	BL1
Years Sampled		8	6	2	1	3	1	8	8	6	5	6	1	1	1	4	4	4	1	3	1
Total # of Replicates		40	28	10	5	15	3	40	40	30	25	30	3	5	5	20	20	20	5	13	5
General Metrics ¹																					
Abundance (# / ft2)	Mean	262.5	498.8	155.8	259.2	91.1	435.3	225.2	243.4	290.6	377.9	175.5	587.0	66.6	79.8	61.7	34.1	124.8	59.0	460.5	48.8
	SD±	184.9	290.9	116.0	--	43.6	--	199.0	176.0	199.1	272.2	110.1	--	--	--	40.5	31.8	57.5	--	298.2	--
# Taxa	Mean	20.5	20.0	16.5	15.0	14.8	13.0	20.1	19.8	20.7	19.8	17.7	21.0	12.0	11.0	12.5	12.8	15.5	14.0	22.7	11.0
	SD±	4.2	1.7	2.1	--	4.9	--	4.4	3.7	3.7	2.9	2.7	--	--	--	2.6	4.8	1.3	--	3.1	--
# EPT Taxa	Mean	11.9	11.5	8.5	6.0	7.8	4.0	11.4	10.8	11.2	11.2	9.2	7.0	6.0	4.0	6.3	5.8	7.8	6.0	13.7	7.0
	SD±	2.2	1.2	2.1	--	1.7	--	2.1	3.1	1.7	2.5	1.6	--	--	--	2.5	3.0	1.0	--	1.2	--
% EPT Taxa	Mean	29.6	20.6	57.6	51.7	27.4	59.0	34.3	35.7	29.2	27.2	35.8	14.8	18.9	64.7	51.6	36.0	21.2	68.8	40.9	21.7
	SD±	12.7	7.0	15.2	--	10.3	--	13.7	8.9	8.8	7.4	14.7	--	--	--	18.7	20.7	12.7	--	16.3	--
% Dominant Taxon	Mean	55.3	56.4	30.7	45.4	53.9	25.1	38.0	39.2	56.0	52.7	43.1	69.0	51.7	41.4	28.3	31.5	50.0	29.8	50.9	70.1
	SD±	20.3	18.0	13.9	--	1.4	--	10.6	10.5	15.0	9.5	16.3	--	--	--	6.2	8.1	11.9	--	16.1	--
% Chironomidae	Mean	55.3	54.1	14.5	42.3	47.7	14.2	30.5	35.9	56.0	52.7	35.5	8.1	6.0	10.0	17.9	31.0	16.9	18.3	50.3	70.1
	SD±	20.3	21.6	1.7	--	13.3	--	13.6	13.6	15.0	9.5	20.8	--	--	--	8.3	8.8	14.8	--	17.3	--
EPT/Chironomidae Ratio	Mean	0.7	0.5	3.9	1.2	0.6	4.1	1.8	1.2	0.6	0.5	1.4	1.8	3.2	6.5	3.4	1.3	8.1	3.8	1.0	0.3
	SD±	0.6	0.4	0.6	--	0.1	--	1.7	0.6	0.3	0.2	0.9	--	--	--	2.2	0.9	14.6	--	0.8	--
Diversity Indices ¹																					
Shannon (H)	Mean	1.66	1.50	2.02	1.21	1.50	1.75	1.97	1.88	1.62	1.75	1.69	1.30	1.59	1.60	1.90	1.90	1.52	1.92	1.66	1.22
	SD±	0.5	0.4	0.2	--	0.1	--	0.2	0.3	0.4	0.2	0.3	--	--	--	0.1	0.2	0.3	--	0.2	--
Evenness (e)	Mean	0.56	0.50	0.72	0.45	0.57	0.68	0.66	0.63	0.54	0.59	0.59	0.43	0.64	0.67	0.76	0.78	0.56	0.73	0.53	0.51
	SD±	0.2	0.1	0.0	--	0.0	--	0.1	0.1	0.1	0.1	0.1	--	--	--	0.1	0.1	0.1	--	0.1	--
Biotic Index																					
Hilsenhoff Biotic	Mean	4.86	5.03	3.28	3.41	4.58	3.93	4.40	4.78	4.98	4.88	4.28	3.34	3.71	2.38	4.01	4.36	3.84	3.35	4.68	5.15
	SD±	0.5	0.4	0.5	--	0.4	--	0.8	0.3	0.3	0.4	0.6	--	--	--	0.5	0.4	0.5	--	0.3	--

Notes:

For sample site locations, refer to Figure 3.13-1.

- 1 Refer to OtterTail (2012b) for definitions of metrics. Shannon (H) and Evenness (e) diversity indices quantify overall biodiversity by measuring the number of species present and how even the number of individuals for each species is distributed in the data set. For example, Shannon (H) is highest when all species present are comprised of an equal number of individuals. The Hilsenhoff Biotic Index is a measure of water quality ranging from 0 to 10 based on the presence of macroinvertebrate families and their tolerance to pollution with 0 being least polluted.
- 2 Excludes orders composing less than 1.0 percent per site. Chironomidae grouped as 1 taxon for multi-year comparisons.

Abbreviations:

EPT = Ephemeroptera, Plecoptera, Trichoptera

Mean = Average of all samples for all years

SD = standard deviation of the mean.

Source: OtterTail 2012b.

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Table 3.13-9: Average Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004 to 2011)

Site ID	Year	n	(mg/kg Wet Weight)											
			Al	Sb ¹	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
DO1	2004	6	131	0.0028	0.18	0.019	0.30	0.73	185	0.047	23.58	0.023	1.00	21.8
	2005	6	115	0.0023	0.18	0.019	0.47	0.88	131	0.026	23.15	0.032	0.84	19.3
	2006	9	94	0.0050	0.25	0.023	0.12	0.84	108	0.024	14.90	0.038	0.72	26.9
	2007	15	68	0.0047	0.17	0.018	0.12	0.69	89	0.023	14.90	0.034	0.93	21.1
	2008	15	83	N/A	0.17	0.018	0.20	0.62	104	0.026	14.55	0.038	0.68	20.5
	2009	15	46	N/A	0.12	0.010	0.06	0.49	58	0.012	23.03	0.027	0.62	15.4
	2010	15	86	N/A	0.14	0.014	0.21	0.67	81	0.038	11.79	0.029	0.88	20.9
	2011	15	70	N/A	0.13	0.014	0.16	0.52	85	0.027	12.19	0.025	.72	17.5
	Grand Mean		86	0.0037	0.17	0.017	0.21	0.68	105	0.028	17.26	0.031	0.80	20.4
	SD		28	0.0013	0.04	0.004	0.14	0.13	41	0.011	5.05	0.006	0.14	3.4
	CV		0.33	0.36	0.25	0.24	0.67	0.19	0.39	0.41	0.29	0.18	0.17	0.17
CR2	2004	6	64	0.0055	0.48	0.015	0.24	0.65	82	0.021	10.98	0.032	1.08	20.5
	2005	6	92	0.0080	0.61	0.019	0.35	0.87	120	0.025	19.98	0.045	0.87	18.2
	2006	3	116	0.0063	0.56	0.025	0.10	0.90	127	0.029	12.10	0.045	0.90	27.5
	2007	15	80	0.0061	0.45	0.016	0.21	0.74	102	0.028	10.69	0.042	1.27	21.7
	2008	15	44	N/A	0.45	0.014	0.17	0.63	77	0.014	7.16	0.048	0.95	22.0
	2009	15	36	N/A	0.31	0.013	0.04	0.61	59	0.012	8.80	0.032	1.12	18.0
	2010	15	103	N/A	0.46	0.013	0.58	0.62	128	0.041	11.03	0.040	0.87	17.0
	2011	15	143	N/A	0.66	0.016	0.52	0.65	258	0.048	13.21	0.042	0.65	17.9
	Grand Mean		85	0.0065	0.50	0.016	0.28	0.71	119	0.027	11.74	0.041	0.96	20.4
	SD		30	0.0011	0.10	0.004	0.18	0.12	27	0.010	4.07	0.006	0.15	3.6
	CV		0.35	0.16	0.19	0.26	0.65	0.18	0.23	0.36	0.35	0.15	0.16	0.18
CR1	2004	15	54	0.0026	0.29	0.016	0.15	0.62	66	0.019	11.96	0.029	1.05	18.3
	2005	15	82	0.0039	0.31	0.025	0.36	1.16	100	0.025	15.65	0.033	1.10	19.5
	2006	25	104	0.0054	0.45	0.026	0.13	0.83	113	0.027	14.95	0.035	0.84	21.4

Table 3.13-9: Average Metal Concentrations in Slimy Sculpin <55mm Long within the Crooked Creek Drainage (2004 to 2011)

Site ID	Year	n	(mg/kg Wet Weight)											
			Al	Sb ¹	As	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Se	Zn
	2007	15	86	0.0049	0.31	0.021	0.15	0.65	87	0.026	11.42	0.027	0.86	19.4
	2008	15	50	N/A	0.29	0.018	0.16	0.58	69	0.017	9.78	0.041	0.85	21.6
	2009	15	79	N/A	0.23	0.012	0.09	0.52	76	0.018	10.66	0.026	0.71	15.5
	2010	15	61	N/A	0.23	0.012	0.18	0.53	57	0.022	12.55	0.029	0.62	19.2
	2011	15	97	N/A	0.23	0.017	0.17	0.54	89	0.034	10.51	0.026	0.65	18.6
	Grand Mean		77	0.0042	0.29	0.019	0.17	0.68	82	0.024	12.18	0.031	0.84	19.2
	SD		19	0.0012	0.07	0.006	0.09	0.23	20	0.004	2.16	0.005	0.17	2.0
	CV		0.25	0.29	0.25	0.31	0.49	0.34	0.25	0.16	0.18	0.17	0.20	0.11
CR0.7	2006	29	109	0.0051	0.43	0.032	0.17	0.98	123	0.028	16.74	0.031	1.01	23.2
	2007	15	94	0.0050	0.30	0.021	0.19	0.70	98	0.027	12.02	0.034	1.03	19.5
	2008	15	42	N/A	0.27	0.016	0.14	0.53	52	0.016	10.25	0.038	0.90	19.9
	2009	15	46	N/A	0.22	0.013	0.05	0.58	47	0.012	9.07	0.022	0.97	15.5
	2010	15	61	N/A	0.21	0.015	0.33	0.56	57	0.028	13.00	0.034	0.67	18.0
	2011	15	70	N/A	0.22	0.017	0.11	0.53	75	0.024	9.88	0.013	0.64	17.0
	Grand Mean		70	0.0051	0.27	0.019	0.17	0.65	75	0.023	11.83	0.032	0.87	18.9
	SD		30	0.0001	0.09	0.008	0.10	0.19	33	0.008	2.95	0.006	0.15	2.8
	CV		0.42	0.02	0.33	0.40	0.63	0.29	0.44	0.34	0.25	0.19	0.17	0.15

Notes:

1 Only a fraction of the samples of antimony were detected above the method detection limit; therefore, data presented here for reference purposes only.
A wet weight to dry weight conversion chart and method detection limits for each analyte can be found in OtterTail 2012b.

Abbreviations:

Al = aluminum

Cr = chromium

Fe = iron

Mn = manganese

Sb = antimony

As = arsenic

Cu = copper

Grand Mean = Average of

n = the number of composite

SD = standard deviation of the means per year

Cd = cadmium

CV = coefficient of
variation (SD/Mean)

of all years sampled

samples analyzed per given year.

Se = selenium

Hg = mercury

Pb = lead

Zn = zinc

Source: OtterTail 2012b.

3.13.2.2 TRANSPORTATION CORRIDORS

3.13.2.2.1 AQUATIC HABITAT

Aquatic Habitat within Kuskokwim River Transportation Corridor

The Kuskokwim River watershed is a basin encompassing approximately 50,200 mi² and is the second largest drainage in Alaska. The Kuskokwim River flows about 900 miles from the headwaters of the Kuskokwim Mountains in the Alaska Interior southwest to the Bering Sea. The proposed transportation corridor extends up the Kuskokwim River from Kuskokwim Bay to the proposed port site at either Angyaruaq (Jungjuk) or, alternatively, Birch Tree Crossing (Figure 3.13-2, and Figure 2.3-42 in Chapter 2, Alternatives). During construction of the pipeline crossing near milepost 240, barge traffic also would travel upriver beyond Stony River to the east and west Kuskokwim River barge landings.

Downriver of Aniak, the river is characterized by low gradient, interconnected meandering channels and sloughs. Tidal influence extends from Kuskokwim Bay upriver to Tuluksak (RM 136). Substantial lateral movement of the channel, which shifts continuously in response to changing levels of flow, has resulted in extensive natural bank erosion, riverbed scour, and high sediment loading. Riverbed substrates primarily consist of a sand/silt/clay composition. Changes in the channel morphology frequently alter riverine habitat through erosion and creation of sand bars (AGRA 1998). Fallen trees, associated with accelerated rates of bank erosion, line most steep banks and provide important refuge and cover for fish. Upstream of Akiak, the river exhibits less lateral movement, although bank erosion is still extensive, and more islands and vegetated sand bars occur than in downstream reaches (AGRA 1998). Near the proposed Angyaruaq (Jungjuk) Port site, the river bed consists primarily of gravel with some cobbles overlain and mixed with silt and sand. Aquatic habitat in the immediate vicinity of the proposed port site is more uniform as the channel is unbraided with no established islands (Figure 2.3-12 in Chapter 2, Alternatives).

Extensive gravel extraction and related barging along the main channel and sloughs of the Kuskokwim River take place from Aniak downriver about 47 miles to the Cenaliulriit Coastal District boundary. This area includes the proposed alternative port site at Birch Tree Crossing. Photo interpretive maps indicate there have been well over 100 discrete material sites along this section of river in recent years. Birch Tree Crossing, located about 12 river miles downriver of Aniak, is one of the largest material sites along the river in this area. Aggregates from this area are in demand for fill and concrete use associated with transportation, flood control, and building projects in Upper and Lower Kalskag, Bethel, and other communities. Aggregate demands for such projects are particularly high along the Lower Kuskokwim River and Yukon-Kuskokwim Delta where these materials are in short supply (ADNR 1988).

Aquatic Habitat within Transportation Road Corridors

Mine Access Road Corridor

In this section, aquatic habitat at crossings along the proposed 30-mile-long, two-lane, 30-foot-wide, all season gravel mine access road corridor will be described moving in a northerly direction beginning at the Angyaruaq (Jungjuk) Port site (Figure 3.13-1, and Figures 2.3-11 and

2.3-12 in Chapter 2, Alternatives). Along the road corridor, 51 streams or drainages would be crossed involving 6 span bridges, for crossings over waters used by Chinook, coho, and chum salmon, and 45 culverts. Construction materials would be excavated from 13 material borrow sites; the largest of which (about 205 acres) would be located at MP 10.4-11.0 just upstream of the juncture of the north and south forks of Getmuna Creek (Table 2.3-9 in Chapter 2, Alternatives).

Jungjuk Creek joins the Kuskokwim River just downstream of the proposed Angyaruaq (Jungjuk) Port site at the south terminus of the mine access road corridor. As the road corridor extends west and north from the port site, it crosses a small unnamed tributary to the Kuskokwim River and two unnamed Jungjuk Creek tributaries. About 2.6 miles west of the port site, the road corridor crosses Jungjuk Creek (JJ1) and then crosses it again at 3.4 miles. The creek in this area has a moderate gradient, a substrate composition dominated by gravel and cobble, and flows that often run clear. Beaver activity is prevalent in most of the drainage (OtterTail 2012b).

As the road corridor continues north, it crosses the South Fork and North Fork of Getmuna Creek. A proposed material borrow site is located between these forks (Figure 2.3-12 in Chapter 2, Alternatives). Getmuna Creek drains an area of 98.6 mi² and is the largest tributary in the Crooked Creek drainage. Getmuna Creek has a repetitive sequence of riffle-run-pool habitat types and is not as sinuous as lower Crooked Creek likely due to its steeper gradient and different geomorphology. Water clarity has been consistently higher at Getmuna Creek than in the mainstem Crooked Creek. This is likely due to the presence of finer textured sediment in the geology of this watershed (OtterTail 2012b). The lower reaches of Getmuna Creek have sand/gravel/cobble substrate and a good frequency and quality of pool habitat. The upper reaches of Getmuna Creek contain numerous riffle areas dominated by a gravel/cobble substrate composition. Large woody debris and off-channel habitats are abundant throughout the drainage (OtterTail 2012b).

An unnamed Creek (FN1) enters the South Fork Getmuna Creek from the south upstream from the North Fork/South Fork confluence. This low- to medium-gradient stream has clean gravel substrate and undercut banks. Another tributary, located north of the North Fork Getmuna Creek, was determined to have limited aquatic habitat, a 1.6-foot-wide channel, and a 10 percent gradient. The remainder of the proposed road corridor (including connections to the proposed airstrip and permanent camp) extends along the divide between the Crooked Creek watershed (to the east) and the Yukon River watershed (to the west) without crossing other tributaries in these drainages until the crossing of Crooked Creek at its northern terminus. Aquatic habitat in the Crooked Creek drainage is described in Section 3.13.2.1.

Birch Tree Crossing Mine Access Road Corridor

Under Alternative 4, the upriver port site would be established at Birch Tree Crossing, 124 miles upriver from Bethel, instead of Angyaruaq (Jungjuk) which is located 199 miles upriver from Bethel. This would reduce the barge travel distance from Bethel to the port site for freight and diesel by 75 miles or 38 percent (Figures 2.3-41 and 2.3-42 in Chapter 2, Alternatives). A 76-mile-long, two-lane, 30-foot-wide, all-season, gravel access road would be constructed for mine support traffic between the Birch Tree Crossing Port site and the mine site. The length of the proposed access road would be 253 percent longer than the 30-mile mine access road constructed under Alternative 2. Preliminary field reconnaissance indicated the route between

the BTC Port site and the mine would cross 40 streams or drainages requiring 8 bridges and 32 culverts (compared to 51 stream or drainage crossings involving 6 bridges and 45 culverts under Alternative 2). In addition, 52 borrow sites would be used to provide materials to construct the gravel road between the BTC and the mine. The largest borrow site (about 205 acres) would be located at MP 16 (Table 2.3-37 in Chapter 2, Alternatives). The Owhat River and the lower reaches of several of its tributaries are classified as EFH under the Magnuson-Stevens Act.

3.13.2.2.2 FISH

Anadromous/Resident Fish and Macroinvertebrates within the Transportation Corridor

Anadromous/Resident Fish

The Kuskokwim River serves as a migration corridor for resident and anadromous fish species and provides diverse, year-round habitat for various life stages of some of these species. Due to the diversity and seasonal abundance of these species, the river supports important subsistence, commercial, and sport fisheries for the region. A summary of the general run timing for adult salmon near the Port of Bethel in the lower river is presented in Table 3.13-10 based on 20 years of records (1984 to 2003). The periods encompass the general arrival times of spawning salmon at weirs located in certain tributaries along the middle and upper Kuskokwim River. Based on records from 1996 to 2011, the annual median passage dates of Chinook, chum, and coho salmon at the George River weir (located upstream of the Crooked Creek confluence) was July 7th, July 17th, and August 28th, respectively (Clark and Blain 2012).

Table 3.13-10: Summary of Kuskokwim River Salmon Run Timing Based on Test Fishery at Bethel, AK 1984-2003

Species	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
Coho													--	X	X	X	--			
Sockeye											--	X	X	--	--					
Chinook											--	X	X	X	--	--				
Chum												--	X	X	X	--	--			
Pink												--	--	X	X	--	--			

Notes:

Shaded periods indicate peak run times while dashed line depict ascending and descending run times.

Sources: FDS No. 05-14 (ADF&G 2005); pink salmon timing based on FMR 08-25 (ADF&G 2008) from Kwethluk River weir in 2004.

As shown in Table 3.13-11, at least 27 species of resident freshwater and anadromous fish are supported by the Kuskokwim River drainage (Brown et al. 2011). None of the species identified as being in the area are listed in Alaska as threatened or endangered. While Chinook salmon are now a stock of concern in Alaska, statutory protections are unchanged.

Table 3.13-11: Fish Species Occurring in the Kuskokwim River Drainage

Fish Species		
Family	Scientific Name	Common Name
Salmonidae	<i>Oncorhynchus tshawytscha</i>	Chinook salmon
	<i>O. keta</i>	Chum salmon
	<i>O. kisutch</i>	Coho salmon
	<i>O. nerka</i>	Sockeye salmon
	<i>O. gorbuscha</i>	Pink salmon
	<i>O. mykiss</i>	Rainbow trout
	<i>Salvelinus malma</i>	Dolly Varden
	<i>S. alpinus</i>	Arctic char
	<i>S. namaycush</i>	Lake trout
	<i>Thymallus arcticus</i>	Arctic grayling
	<i>Prosopium cylindraceum</i>	Round whitefish
	<i>Coregonus pidschian</i>	Humpback whitefish
	<i>C. sardinella</i>	Least cisco
	<i>C. nasus</i>	Broad whitefish
	<i>C. laurettae</i>	Bering cisco
	<i>Thymallus arcticus</i>	Sheefish
Catostomidae	<i>Catostomus catostomus</i>	Longnose sucker
Cottidae	<i>Cottus cognatus</i>	Slimy sculpin
Esocidae	<i>Esox Lucius</i>	Northern pike
Umbridae	<i>Dallia pectoralis</i>	Alaska blackfish
Petromyzontidae	<i>Lethenteron alaskense</i>	Alaskan brook lamprey
	<i>L. camtschaticum</i>	Arctic lamprey
Gadidae	<i>Lota lota</i>	Burbot
Gasterosteidae	<i>Pungittius pungittius</i>	Ninespine stickleback
Cyprinidae	<i>Couesius plumbeus</i>	Lake chub
Osmeridae	<i>Hypomesus olidus</i>	Pond smelt
	<i>Osmerus mordax mordax</i>	Rainbow smelt
Total Species Count: 27		

Source: Brown et al. 2011.

The life history for salmon species of importance to subsistence, commercial, and recreational fisheries are briefly summarized below (Groot and Margolis 1991; Mecklenburg et al. 2002; Morrow 1980; NRC 2004; Scott and Crossman 1973; FWS 1988).

The Kuskokwim River Chinook salmon stock consists of an array of many populations throughout the drainage with a run strength that has been highly variable over the past two decades and historically low returns since 2010 (ADF&G 2013j). Chinook salmon adults typically enter the Kuskokwim River system in June and July and primarily spawn in the main channel of tributaries from mid- to late summer. Fry emerge from redds the following spring and typically spend 1 year in tributaries and backwater rearing areas before their seaward migration. Smolts migrate to the ocean in late spring, following ice breakup.

Chum salmon tend to be the most abundant salmon in the Kuskokwim River basin. Adults typically enter the Kuskokwim River in late June and July and spawn primarily in tributaries from July to August, depending on location. Chum salmon eggs typically hatch and emerge from redds in May. While still at a relatively small size, fry migrate downstream soon after emergence entering the Kuskokwim Bay estuary in May and June.

Coho salmon adults typically enter the Kuskokwim River in late July and spawn primarily in tributaries in September to early October. Fry emerge in May or June and typically spend 1 or 2 years in freshwater tributaries before migrating to the ocean in late spring or early summer. Numerous clear-water tributaries of the Kuskokwim River provide important rearing and overwintering habitat for juvenile coho salmon.

Sockeye salmon adults typically enter the Kuskokwim River in June and July and spawn primarily in tributaries in August and early September. Young emerge from redds the following April to June and typically spend 1 or 2 years in fresh water lakes before migrating to the ocean in late spring/early summer.

Pink salmon are the least abundant salmon in the Kuskokwim River system. Adults enter the river in early to mid-summer and spawn primarily in tributaries in mid- to late summer. Fry emerge in May and immediately begin their seaward migration.

In recent years, a trend of low productivity and abundance of Kuskokwim River Chinook salmon stocks indicates the run has become insufficient to meet the escapement levels necessary to sustain the run while also providing the levels of harvest needed by the subsistence community as established by the Alaska Board of Fisheries. To address such concerns and provide a basis for future decisions affecting Chinook salmon stocks and subsistence fisheries, a panel of experts has outlined a series of proposed studies described in the Arctic-Yukon-Kuskokwim Chinook Salmon Research Action Plan (Schindler et al. 2013). Objectives of the plan involve the evaluation of several key factors that could be contributing to the sharp decline in Chinook salmon abundance and productivity. These include:

- Density dependent feedbacks in population dynamics that may cause changes in fish abundance that could persist for 10-year or more periods of time;
- Changes in the suitability or productivity of freshwater habitats used for spawning, rearing, and migration;
- Changing physical and biological ocean conditions in the Bering Sea that cause an increase in mortality of Chinook salmon during their early marine life cycle;
- Human-caused changes in oceans that reduce growth and survival of Chinook salmon;
- Mortality of Chinook salmon from incidental capture during non-salmon marine fisheries;

- Effects of selective fishing and natural mortality on the genetic character of stocks resulting in alteration of fish size, sex ratio, and composition of life history types, declines in egg deposition, and stock recruitment; and
- Effects of pathogens that have increased mortality rates of Chinook salmon during upstream migration.

Other salmon-related studies planned through the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative for the Kuskokwim River watershed may be accessed at: <http://www.aykssi.org/projects/?keyword=45>.

In 2011, surveys were conducted by OtterTail Environmental, Inc. in the Kuskokwim River to document fish populations near the proposed Angyaruaq (Jungjuk) Port site. The selected sampling sites were located at the port site (KU8) and in areas upstream (KU9, 10, 11, 12) and just downstream (KU13, 14, 15) to provide representative sampling in the proposed port site vicinity (Figure 3.13-1). Each sampling site contained slightly different habitat types which required different sampling methods. Most of the fish were captured with seines during these surveys, but fyke net sets and electrofishing also were conducted. Across all sites, the most common species collected were longnose sucker, Arctic grayling, humpback whitefish, and round whitefish. Juveniles of all five Pacific salmon were collected in the vicinity of the proposed port site. Other species collected included least cisco, sheefish, ninespine stickleback, burbot, northern pike, Dolly Varden, and lamprey species. These and other non-salmon species, some of which are described below, are important to the subsistence fisheries and as forage for upper level predators along the river.

In 2014, the abundance and distribution of juvenile Pacific salmon and resident fishes were evaluated using seines along shorelines at five select reaches of the Kuskokwim River where relatively narrow channels exist (Owl Ridge 2014a). This included a site near the Birch Tree Crossing port site alternative. The surveys, which involved over 250 seine hauls conducted from July 16-25 and August 27-September 6, yielded only a few juvenile salmon (one Chinook, six coho, and 28 sockeye). In contrast, surveys conducted during the August 27-September 6 sampling period in two Kuskokwim River tributaries, the Holokuk and Aniak rivers, resulted in the collection of 164 Chinook, 267 coho, and 46 sockeye salmon juveniles. During the July sampling period in the Kuskokwim River, a total catch of over 14,000 fish consisted of nearly 92 percent longnose sucker, with slimy sculpin (4.5 percent) and arctic grayling (1.9 percent) comprising the next most abundant species. During the late August sampling period, 9,290 fish were collected comprised of over 78 percent longnose sucker, 6.9 percent arctic grayling, and 6.3 percent slimy sculpin. Results of the study suggest that few juvenile salmon rear within the mainstem Kuskokwim River. The study further suggests that juvenile salmon not out-migrating to the estuary in May and June likely remain within local tributaries to rear and overwinter until the following spring. This also is consistent with field studies conducted in the Kuskokwim River during 2015 (May 15 to June 4 and June 19 to 25) where 80 percent of the fish collected in nearshore seine hauls were outmigrating juvenile salmon.

Other species of importance to subsistence fisheries in the Kuskokwim River drainage include broad whitefish, humpback whitefish, and round whitefish, least cisco, sheefish Arctic grayling, rainbow smelt, northern pike, burbot, and Alaska blackfish. The following paragraphs summarize life history and background information for some of these species.

Whitefish

Broad whitefish, humpback whitefish, sheefish (inconnu), and least cisco in the Kuskokwim River system generally exhibit similar life history traits. A variety of studies have documented information regarding distribution and migration patterns, population size, size and age structure, natural mortality, rearing/breeding habitats, and harvest numbers. Whitefish are known to overwinter in large rivers and typically enter freshwater tundra ponds and lakes during April or May. They remain in these waters to feed over the summer until oxygen levels decrease causing them to return to the mainstem of the Kuskokwim River to begin migrating to fall spawning locations (Alt 1979; Reist 1997; Harper et al. 2007, 2008, 2009, 2012). Although some species of whitefish may remain in freshwater their entire lives, others overwinter in brackish waters in the lower Kuskokwim River migrating upstream in early June through late September where peak spawning occurs in late September to November (Harper et al. 2009, 2012). While less is known about spawning preferences and timing for broad whitefish and least cisco, humpback whitefish spawning has been documented to occur in late September and early October in areas with relatively swift currents and gravel substrates (Alt 1979; Chang-Kue and Jessop 1997; Fleming 1996; Brown 2006). Whitefish are broadcast spawners releasing their eggs and milt into the current where fertilized eggs then settle to the bottom to lodge in gravel while maturing over the winter. In the spring, river currents carry fry to the lower river and estuary areas where the fish rear.

Radio telemetry studies conducted from 2004 to 2009 have documented the timing and seasonal distribution of broad whitefish, humpback whitefish, and least cisco from Whitefish Lake (south of Aniak) and the Kuskokwim River (Harper et al. 2008, 2009, 2012). The whitefish tracked during these studies were found to consist of mixed stocks that follow complex migration patterns over long distances with migrations occurring at different times of the year. Some migrate up the Kuskokwim River from early June through late September while others migrate from mid-September through early October. Broad whitefish migrated out of Whitefish Lake in early July, September, and October with some overwintering in Ophir Creek, a tributary to Whitefish Lake. Broad whitefish were tracked to possible main channel fall spawning areas near the confluence of the Swift River and to an area between the villages of McGrath and Medfra. Humpback whitefish radio-tagged from Whitefish Lake were found to migrate to suspected spawning areas in the Holitna, Swift, and Big rivers in the upper Kuskokwim system. Tracking results indicated that Whitefish Lake was used by multiple stocks of whitefish before traveling to several different upriver spawning areas and that multiple year classes of these fish used the lake as a year to year feeding area. Spawning habitat documented during the fish tracking studies was characterized as consisting of swift current with gravel substrates. The documented migration patterns indicate that whitefish travel long distances and return to similar spawning areas each year. Stocks in Whitefish Lake and along the Kuskokwim River are vulnerable to harvest by subsistence fisheries in the Kuskokwim River drainage.

Sheefish

Sheefish, or inconnu, is the largest species of whitefish in the Kuskokwim River system reaching lengths of 30 inches by age 8, with the record sport-caught sheefish in northwestern Alaska weighing 53 pounds. Sheefish migrate over long-distances; some over 1,000 miles within a single summer. Sheefish in major Alaskan river drainages such as the Kuskokwim, Yukon, Selawik, and Kobuk rivers typically overwinter in the brackish waters of the bays. During spring break up, many sheefish travel upriver to feed. Some will migrate upriver later in the

summer to spawn. Some sheefish, called “residents” do not migrate to the bays at all; instead, remaining in freshwater their entire lives. Sheefish may take up to 2 months to reach spawning and overwintering locations. Spawning sheefish return to their natal spawning grounds and release eggs that are broadcast in shallow waters over gravel of varying size. Eggs typically hatch in early spring before ice out; juveniles subsequently drift downriver to eddies, off-channel lakes, and estuary areas near the river mouth seeking refuge and food that includes insects and other small prey. Adults feed almost entirely on herring, smelt, juvenile northern pike, sticklebacks, lamprey ammocoetes, and other small outmigrating juvenile fish. Kuskokwim River sheefish tend to travel to and feed in the same areas each spring and summer (ADF&G 2014a). Radiotelemetry and aerial surveys conducted from 2007–2011 by Stuby (2012), have documented seasonal distributions, spawning locations, and movements of sheefish throughout the Kuskokwim River mainstem and its tributaries. The investigations revealed that, during summer, sheefish traveled to and between the mouths of major Kuskokwim River tributaries to feed and annually returned to these same areas. Upstream migrations to spawning areas in Highpower Creek and Big River occurred from late July to mid-September with spawning taking place from late September through early October. Tributaries used for feeding included the Johnson River and Kongeruk River in the lower river, and the Holitna River near Sleetmute in the middle river. Post-spawning outmigrations of sheefish were found to occur during a 1 to 1.5-week period in mid-October with most fish returning to overwinter in the lower river while a smaller number of fish overwintered in the Middle Kuskokwim River and Holitna River.

Arctic Grayling

Arctic grayling are a common species of resident whitefish within the Kuskokwim basin, noted for its broad sail-like dorsal fin. The species is long-lived in Alaska living up to 32 years. Grayling are spring spawners, spawning for the first time between the ages of 4 and 7 years and at a length of about 10 to 12 inches. They broadcast spawn from 1,500 to 30,000 eggs with eggs lodging in between pebbles and gravel. Eggs hatch after about three weeks with fry immediately moving to edge habitats along stream banks where they grow quickly; reaching a length of 2 to 4 inches by the end of summer (ADF&G 2015j). Based on studies conducted in the spring and early summer of 2015 on the mainstem Kuskokwim River, juvenile grayling were found to be relatively common, comprising the third most abundant fish in the nearshore catch (Owl Ridge 2015b). Adult grayling were not found in the mainstem Kuskokwim River, but were observed in tributary streams such as the Holokuk and Aniak rivers (Starkes 2015). During summer, Arctic grayling feed on a variety of invertebrates but primarily on drifting aquatic insects, including black flies, mayflies, stone flies, and caddis flies. They also feed on salmon eggs during spawning runs, smaller fish, or terrestrial insects. During winter, Arctic grayling feed minimally, conserving energy by occupying lakes and pools in streams. Grayling tolerate low dissolved oxygen levels, a common condition beneath the ice, and have evolved different migratory strategies depending upon the environmental conditions in the stream basins they inhabit. While some Arctic grayling may use different stream basins for overwintering, summer feeding, and spawning, others may complete their entire life in only a short section of a single stream or lake. Shortly after ice-out, adult grayling begin to migrate upstream to spawning grounds. Immediately after spawning, they migrate to summer feeding areas traveling distances that can vary from less than a mile to over 100 miles. In the early fall, grayling begin to slowly migrate back to deeper pools that do not freeze completely during winter (ADF&G 2015j).

Rainbow Smelt

Rainbow smelt are a principal prey species important to pike, sheefish, and other species and are harvested by the subsistence communities. Rainbow smelt are an anadromous smelt species with poorly documented populations in the Kuskokwim River and elsewhere in southwest Alaska. In other river systems, these fish are preyed upon by various commercially and recreationally valuable coastal marine species (Buckley 1989). During spring ice out, or soon thereafter, rainbow smelt have been observed to begin their spawning migration from Kuskokwim Bay and the tidally influenced reaches of the lower Kuskokwim River near Tuluksak. Spawning generally occurs during a brief one- to two-day period in the vicinity of Lower and Upper Kalskag, where eggs and milt are broadcast into the current along the riverbed. Fertilized eggs adhere to river substrates and hatch in less than a month. Until recently, specific spawning habitat in the river was only informally delineated based on general observations (Cannon 2013). In other river systems, rainbow smelt spawning is reported to be associated with specific substrate types (sand, gravel, small boulders, and aquatic vegetation) located upriver from tidally influenced waters since salinities of 12-14 parts per thousand have been documented to be fatal to eggs (Buckley 1989). Water velocity, substrate type, and egg density are all reported to be important factors to egg survival (Sutter 1980), although Clayton (1976) indicates that spawning site selection by rainbow smelt in the Parker River of Massachusetts was influenced largely by water velocity rather than depth or substrate. In certain Alaska rivers, potential threats to rainbow smelt populations may result from overharvest and habitat alteration caused by resource extraction practices that affect instream flows, cause blockages or delays to fish passage, degrade water quality, or cause sedimentation (ADF&G 2006c). In the Kuskokwim River, spawning habitat disruption and sedimentation can result from natural flooding, ice break up, bank erosion, and riverbed scour (from both natural causes and marine traffic). Depending on water temperature, eggs spawned in late May typically will incubate for about 21 days. During this time, the eggs are susceptible to disruption until incubation is completed and flows carry the larvae downstream to the estuary. In 2014 and 2015, surveys were conducted to determine the timing, distribution, and habitat associations of rainbow smelt spawning in the Kuskokwim River. The 2014 survey revealed that spawning, which ultimately took place upstream of Upper Kalskag over a two-day period from May 21-22, occurred along a distance of about 4 miles of gravel and sand substrates at depths of 5 to nearly 14 feet on the sides of the mainstem channel (Owl Ridge 2014a). During 2015, rainbow smelt also spawned in late May but at two locations downriver from lower Kalskag, in narrower river segments with coarse gravels and at a deeper mean depth of 14.5 feet (range 8.7 to 23.4 feet) near the thalweg where barge traffic would travel (Owl Ridge 2015a).

Northern Pike

Northern pike are a large resident freshwater species ranging from Alaska's Interior to the Arctic coast, from the Canadian border to the Seward Peninsula, and southwest to Bristol Bay drainages. During recent years, illegally stocked northern pike have established themselves in many Alaskan streams, however, those in the Kuskokwim basin are native (Cannon 2014b). Northern pike spawn in the spring of the year soon after ice out. A 25-pound female may contain up to 500,000 eggs deposited in the grassy margins of slow moving streams, or off-channel backwaters, with incubation requiring about 30 days. Most northern pike overwinter in the deep, slow waters of large rivers. In spring, northern pike migrate from overwintering areas to spawning grounds and then return to summer feeding areas generally a short distance away. During summer, migration patterns are localized involving warm, shallow feeding areas

(ADG&G 2015k). In 2014, several subadult to adult northern pike were captured in the shore zone of the mainstem Kuskokwim River during summer months (Owl Ridge 2014f). These fish often were observed within or along the edge of off-channel backwaters, but also were found in the nearshore mainstem and side channels (Starkes 2015). Within interior Alaska, northern pike are slow growing where 12-inch fish are 2 to 3 years old and 15-pound fish are 10 to 17 years old. While young northern pike feed on small crustaceans and insects, adults feed on a variety of fish species and sizes including whitefishes, suckers, burbot, smaller pike, and juvenile salmon. Large adults also have been documented to feed on voles, shrews, red squirrels, and small waterfowl (ADF&G 2015k).

Burbot

Burbot occupy most large clear and glacial-fed rivers and many lakes throughout most of Alaska. The species is relatively long lived and slow growing, reaching ages in excess of 20 years. Burbot typically require 5 to 7 years to reach sexual maturity at a length of about 18 inches (ADF&G 2015l). During fish surveys conducted in the spring of 2015, burbot were uncommonly captured along nearshore waters in the mainstem Kuskokwim but were occasionally captured in cobble shoal and run habitats (Owl Ridge 2015a). Within the Kuskokwim River basin, burbot populations are considered robust. In late winter, burbot spawn under the ice where they have been observed in dense concentrations. Spawning burbot can produce over a million eggs, broadcast spawning into the water column where the eggs and milt settle and fall to the bottom. In rivers, burbot spawn in low velocity areas in main channels and side-channels behind sand or gravel bars. They tend to prefer river substrates consisting of fine gravel, sand, and fine silt. The spawning season is relatively short lasting approximately 2 to 3 weeks during low water temperatures. Incubation rates are long, ranging from 41 to 128 days, depending upon water temperatures (McPhail and Paragamian 2000). Young burbot feed mainly on insects and other invertebrates but by the age of 5 or 6 they begin feeding almost exclusively on fish. While whitefishes, sculpins, lampreys, and other burbot are common food items, mice or shrews are occasionally consumed (ADF&G 2015l).

Alaska Blackfish

The Alaska blackfish is a small freshwater resident species (seldom larger than 8 inches) that typically occupies lowland swamps, ponds, rivers, and lakes in areas of dense aquatic vegetation (ADF&G 1994). Blackfish primarily feed on aquatic invertebrates and insect larvae (Chlupach 1975). Spawning occurs from May to August, with the possibility of individual fish spawning several times a year. Eggs adhere to vegetation for a relatively short period (about 9 days at 54°F) before hatching. Reproductive maturity has been documented to occur when the fish reach a length of approximately 3 inches. The species is unique because it possesses a modified esophagus that is capable of gas absorption. This allows the fish to breathe atmospheric oxygen and live in small stagnant tundra or muskeg pools that are almost devoid of oxygen during the summer, and to survive in moist tundra mosses during extended dry periods (ADF&G 1994). Alaska blackfish have been documented within the Kuskokwim drainage (Scott and Crossman 1973) and are locally harvested for subsistence use, though now at much lower than historical levels (LaVine et al. 2007). The species has been documented to occur at low densities, generally two fish per 300 linear feet or less within mainstem Crooked Creek within the project area (ADF&G 2010; OtterTail 2012b; Table 3.13-5).

Fish Species of the Kuskokwim Management Area

The Kuskokwim Management Area includes the Kuskokwim River drainage and all waters that flow into the Bering Sea between Cape Newenham and the Naskonat Peninsula, and Nunivak and St. Matthew Islands. The Kuskokwim Management Area is divided into four commercial fishing districts with Districts 1 and 4 being most relevant to this discussion. District 1 includes the Lower Kuskokwim River and District 4 extends from the mouth of Weelung Creek to the Arolik River (approximately 7 miles north of Quinhagak to approximately 4 miles south of Quinhagak) and expands 3 miles from the coast into Kuskokwim Bay. Districts 1 and 4 support important subsistence, commercial, and sport fisheries.

As presented in Table 3.13-12, at least 32 species of marine and anadromous fish are supported by the Kuskokwim Management Area within the proposed transportation corridor (Brazil et al. 2013). Some of these species also utilize other segments of the Kuskokwim River, as previously shown in Table 3.13-11. None of these species are listed in Alaska as threatened or endangered.

Table 3.13-12: Marine, Anadromous, and Resident Fish Species
Occurring in the Kuskokwim Management Area

Fish Species		
Family	Scientific Name	Common Name
Salmonidae	<i>Oncorhynchus tshawytscha</i>	Chinook salmon
	<i>O. keta</i>	Chum salmon
	<i>O. kisutch</i>	Coho salmon
	<i>O. gorbuscha</i>	Pink salmon
	<i>O. nerka</i>	Sockeye salmon
	<i>Salvelinus malma</i>	Dolly Varden
	<i>S. alpinus</i>	Arctic char
	<i>S. namaycush</i>	Lake trout
	<i>Thymallus arcticus</i>	Arctic grayling
	<i>Coregonus pidschian</i>	Humpback whitefish
	<i>C. sardinella</i>	Least cisco
	<i>C. nasus</i>	Broad whitefish
	<i>C. autumnalis</i>	Arctic cisco
	<i>Stenodus leucichthys</i>	Sheefish
Cottidae	<i>Oligocottus maculosus</i>	Tidepool sculpin
	<i>Megalocottus platycephalus</i>	Belligerent sculpin
	<i>Myoxocephalus quadricornis</i>	Fourhorn sculpin
Umbridae	<i>Dallia pectoralis</i>	Alaska blackfish
Petromyzontidae	<i>Entosphenus tridentatus</i>	Pacific lamprey
	<i>Lethenteron camtschaticum</i>	Arctic lamprey
Gadidae	<i>Gadus macrocephalus</i>	Pacific cod

Table 3.13-12: Marine, Anadromous, and Resident Fish Species
Occurring in the Kuskokwim Management Area

Fish Species		
Family	Scientific Name	Common Name
	<i>Eleginus gracilis</i>	Saffron cod
Gasterosteidae	<i>Pungittius pungittius</i>	Ninespine stickleback
	<i>Gasterosteus aculeatus</i>	Threespine stickleback
Osmeridae	<i>Osmerus villosus</i>	Capelin
Pleuronectidae	<i>Platichthys stellatus</i>	Starry flounder
	<i>Pleuronectes glacialis</i>	Arctic flounder
	<i>Limanda aspera</i>	Yellowfin sole
	<i>Parophrys vetulus</i>	English sole
	<i>Hippoglossus stenolepis</i>	Pacific halibut
Hexagrammidae	<i>Hexagrammos stelleri</i>	Whitespotted greenling
Clupeidae	<i>Clupea pallasii</i>	Pacific herring
Total Species Count: 32		

Salmon, herring, halibut, sheefish, whitefish, rainbow smelt, char, Arctic grayling, Arctic lamprey, and saffron cod are among the important species for commercial, subsistence, or recreational fisheries in marine and freshwaters of the Kuskokwim Management Area. In Kuskokwim Bay, commercial salmon fisheries open in late June, beginning with Chinook salmon and are followed by sockeye, chum, and coho salmon.

The Kuskokwim Management Area also includes a large subsistence herring fishery. The herring stocks utilized by the subsistence fishery are the same stocks targeted by the commercial fishery, although no commercial herring harvest has occurred in the Kuskokwim Area since 2006 when 390 tons were collected. Herring harvest peaked in the mid-1990s when market value was high, but then declined as market value decreased in the following decade. Although only a few surveys of herring subsistence harvests have been conducted and no data after 1996 exist, data suggest that approximately 110 tons of herring have been harvested annually by the Kuskokwim Delta villages (ADF&G 2013h).

The Bering Sea halibut fishery is also important commercially and as a subsistence fishery. The most recent data available for Pacific halibut fisheries in this area are from the 2010 sport harvest and the 2011 subsistence harvest. Sport harvest records for Pacific halibut show that 184 halibut were caught in the Arctic-Yukon-Kuskokwim area in 2010, however, none were caught in the Kuskokwim River and Bay drainages (Jennings et al. 2011). Subsistence harvest records indicate that approximately 6,168 pounds of halibut were harvested in the Bering Sea Coast area, with the majority harvested from the Yukon-Kuskokwim Delta area, with a smaller component of the harvest from Norton Sound (Fall and Koster 2013). According to the International Pacific Halibut Commission's 2011 Annual Report, the commercial catch for the

entire Bering Sea was approximately 3.4 million pounds, however, data are unavailable for the Kuskokwim Bay area.

Kuskokwim River Subsistence and Commercial Fisheries

Subsistence fishing has occurred on the Kuskokwim River for thousands of years. The commercial fishery dates back to the late 1800s, when harvested fish were primarily sold locally to dog mushers (Oswalt 1990). The first recorded commercial harvest for export occurred in 1913 (Pennoyer et al. 1965). Management was under federal control from the early 1900s through 1959 with fluctuating harvest limits and commercial closures. Beginning in the 1960s, the State of Alaska assumed management responsibility for the fisheries, and the Alaska Department of Fish and Game began regulating commercial and subsistence harvest by imposing restrictions on gear, fishing areas, and fishing time, but did not restrict the allowable harvest for subsistence. The largest annual commercial harvest of Chinook salmon occurred in the early and late 1970s, early and late 1980s, and early 1990s (Table 3.13-14). With the growth of the subsistence fishery, the directed commercial fishery for Chinook salmon was eliminated in 1987 (Ward et al. 2003, Brazil et al. 2013).

The Kuskokwim River subsistence fishery has been one of the largest in Alaska (Carroll and Patton 2010; Merritt 2001). In some communities, fish have contributed as much as 85 percent and salmon 53 percent of the total pounds of the annual fish and wildlife harvested (Brazil et al. 2013). As reported by ADF&G, the Kuskokwim drainage contains 38 communities and approximately 4,600 households within the river's lower, central, and upper regions. Of these, more than 1,500 households currently subsistence fish with additional households involved in fish processing. The river's lower region includes the community of Bethel, the river's regional hub, and extends from Kuskokwim Bay upriver to the Tuluksak River. The central region extends from the Tuluksak River to the Village of Chuathbaluk. The upper region extends past the community of Crooked Creek to the major headwater tributaries near the communities of Takotna, McGrath, Medfra, and Nikolai (ADF&G 2014b).

The Kuskokwim River subsistence salmon fishery has not required licenses or permits, although participants in this and other Alaska subsistence fisheries must be state residents for the prior twelve months to be eligible to harvest salmon for subsistence uses. Subsistence harvest methods include the use of set and drift nets, fish wheels, rod and reel, and occasionally beach seines. There are generally no limits on the number of salmon that can be taken by individuals or households for subsistence purposes in the Kuskokwim area but limits and restrictions are established for rod and reel harvests, net length and mesh size. In addition, rolling subsistence closures are implemented at certain times and locations (ADF&G 2014b).

Information on the customary uses of subsistence fisheries harvests, including salmon and non-salmon subsistence harvest surveys, are developed at the community level by the ADF&G Division of Subsistence and the Division of Commercial Fisheries with cooperation and approval from local Village Councils. In addition, local and traditional ecological knowledge (TEK) research is periodically conducted and published in Division of Subsistence Technical Papers in order to document and share knowledge and observations of the local people across multiple generations (ADF&G 2014b).

A study by LaVine et al. (2007) has documented local and TEK from 1916 to 2004 associated with the life histories, migration, spawning, distribution, past and present subsistence activities, and long-term trends related to anadromous and freshwater resident subsistence fish

populations of the lower Kuskokwim Bay area. Based on the research, the most important fish species for local subsistence harvest over the past decades, and still widely consumed today, involved Chinook, sockeye, chum, and coho salmon, Dolly Varden, and rainbow smelt. Chinook salmon were reported to be harvested in greater quantities in more recent decades, compared to years ago, due to more efficient harvest technologies (e.g., stronger nets and better boats). Rainbow smelt were reported to be consistently widespread in the area, abundant, and accessible in large quantities from fall to late spring. Other species of importance harvested intermittently or for special purposes included spawned out sockeye salmon, Arctic grayling, round whitefish, rainbow trout, and Bering cisco. Alaska blackfish was once a very important species for subsistence use but its use has declined in recent years due to other preferred species. Over the years, Arctic char, lake trout, burbot, and northern pike were reported to be seldom available due to their distance from the Kuskokwim Bay area or were taken incidental to harvests of other preferred species.

Based on an analysis of the 2011 and 2012 subsistence fishery for the Lower, Middle, and Upper Kuskokwim Management Areas, including North Kuskokwim Bay, the 2002-2012 10-year running average subsistence salmon harvest was determined to include 82,099 Chinook, 62,566 chum, 41,093 sockeye, and 37,173 coho salmon (Shelden et al. 2014). In 2010, Chinook salmon stocks in the Kuskokwim River began a sharp decline that has continued since then. The reduced run size and escapement in recent years represent some of the lowest recorded in 35 years, except for the mid-1980s and the year 2000 (Table 3.13-13). The reduced run size has affected harvest success and the subsistence lifestyle along the river. The 2012 estimated subsistence harvest of Chinook in the Kuskokwim Management Areas was 22,527, well below the 82,099 10-year running average previously mentioned (Shelden et al. 2014).

Table 3.13-13 presents estimates of the historic total run abundance and escapement for Chinook salmon stocks in the Kuskokwim River between 1976 and 2011 (Bue et al. 2012). The reduced run abundance of adult Chinook salmon in recent years is reflected in the declining annual subsistence harvest. Subsistence and commercial harvest data extending back to the 1960s, including 10-year running averages for Chinook, chum, sockeye, and coho salmon, are described in ADF&G's 2011 and 2012 Kuskokwim Area Management Reports and are presented in Table 3.13-14 through Table 3.13-17 (Brazil et al. 2013; Elison et al. 2015).

Table 3.13-13: Estimated Total Run and Escapement for Kuskokwim River
Chinook Salmon, 1976 through 2011

Year	Estimated Total Run	95% Confidence Bounds		CV	Estimated Escapement	95% Confidence Bounds		CV
		Lower	Upper			Lower	Upper	
1976	233,967	185,000	300,000	13%	143,420	94,453	209,453	20%
1977	295,559	230,000	385,000	13%	201,852	136,293	291,293	20%
1978	264,325	210,000	330,000	12%	180,853	126,528	246,528	17%
1979	253,970	190,000	350,000	16%	157,668	93,698	253,698	26%
1980	300,573	230,000	410,000	15%	203,605	133,032	313,032	23%
1981	389,791	300,000	515,000	14%	279,392	189,601	404,601	20%
1982	187,354	160,000	225,000	9%	80,353	52,999	117,999	21%
1983	166,333	135,000	210,000	12%	84,188	52,855	127,855	23%
1984	188,238	150,000	250,000	14%	99,062	60,824	160,824	26%
1985	176,292	140,000	235,000	14%	94,365	58,073	153,073	26%
1986	129,168	105,000	160,000	11%	58,556	34,388	89,388	24%
1987	193,465	155,000	270,000	15%	89,222	50,757	165,757	33%
1988	207,818	180,000	250,000	9%	80,055	52,237	122,237	22%
1989	241,857	205,000	295,000	9%	115,704	78,847	168,847	20%
1990	264,802	230,000	320,000	9%	100,614	65,812	155,812	23%
1991	218,705	185,000	270,000	10%	105,589	71,884	156,884	21%
1992	284,846	240,000	350,000	10%	153,573	108,727	218,727	18%
1993	269,305	220,000	340,000	11%	169,816	120,511	240,511	18%
1994	365,246	285,000	485,000	14%	242,616	162,370	362,370	21%
1995	360,513	295,000	450,000	11%	225,595	160,082	315,082	18%
1996	302,603	235,000	405,000	14%	197,092	129,489	299,489	22%
1997	303,189	240,000	395,000	13%	211,247	148,058	303,058	19%
1998	213,873	170,000	275,000	13%	113,627	69,754	174,754	24%
1999	189,939	150,000	240,000	12%	112,082	72,143	162,143	20%
2000	136,618	115,000	165,000	9%	65,180	43,562	93,562	20%
2001	223,707	180,000	280,000	11%	145,232	101,525	201,525	18%
2002	246,296	200,000	300,000	10%	164,635	118,339	218,339	15%
2003	248,789	205,000	295,000	9%	180,687	136,898	226,898	13%
2004	388,136	320,000	465,000	10%	287,178	219,042	364,042	13%
2005	366,601	305,000	435,000	9%	275,598	213,997	343,997	12%
2006	307,662	255,000	375,000	10%	214,004	161,342	281,342	14%

Table 3.13-13: Estimated Total Run and Escapement for Kuskokwim River
Chinook Salmon, 1976 through 2011

Year	Estimated Total Run	95% Confidence Bounds		CV	Estimated Escapement	95% Confidence Bounds		CV
		Lower	Upper			Lower	Upper	
2007	273,060	230,000	320,000	8%	174,943	131,883	221,883	13%
2008	237,074	200,000	285,000	9%	128,978	91,904	176,904	17%
2009	204,747	170,000	250,000	10%	118,478	83,731	163,731	17%
2010	118,507	105,000	140,000	8%	49,073	35,566	70,566	18%
2011	133,059	110,000	160,000	10%	72,097	49,037	99,037	18%

Notes:

The upper and lower bound represent the 95% confidence interval, or limits of uncertainty associated with the total run or escapement estimate, based on the negative log likelihood profiles for each parameter; CV is estimated as the standard deviation divided by the estimate where standard deviation is estimated by dividing the width of the 95% confidence interval by 2 x 1.96.

Source: Bue et al. 2012.

Table 3.13-14: Chinook Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1960	5,969	—	18,887	—	—	—	24,856	—
1961	18,918	—	28,934	—	—	—	47,852	—
1962	15,341	—	13,582	—	—	—	28,923	—
1963	12,016	—	34,482	—	—	—	46,498	—
1964	17,149	—	29,017	—	—	—	46,166	—
1965	21,989	—	24,697	—	—	—	46,686	—
1966	25,545	—	49,325	—	285	—	75,155	—
1967	29,986	—	59,913	—	766	—	90,665	—
1968	34,278	—	32,942	—	608	—	67,828	—
1969	43,997	—	40,617	—	833	—	85,447	—
1970	39,290	22,519	69,612	33,240	857	—	109,759	56,008
1971	40,274	25,851	43,242	38,312	756	—	84,272	64,498
1972	39,454	27,987	40,396	39,743	756	—	80,606	68,140
1973	32,838	30,398	39,093	42,424	577	—	72,508	73,308
1974	18,664	32,480	27,139	42,885	1,236	—	47,039	75,909

Table 3.13-14: Chinook Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1975	22,135	32,632	48,448	42,698	704	—	71,287	75,997
1976	30,735	32,646	58,606	45,073	1,206	—	90,547	78,457
1977	35,830	33,165	56,580	46,001	1,264	33	93,707	79,996
1978	45,641	33,750	36,270	45,668	1,445	116	83,472	80,300
1979	38,966	34,886	56,283	46,000	979	74	96,302	81,864
1980	35,881	34,383	59,892	47,567	1,033	162	96,968	82,950
1981	47,663	34,042	61,329	46,595	1,218	189	110,399	81,671
1982	48,234	34,781	58,018	48,404	542	207	107,001	84,284
1983	33,174	35,659	47,412	50,166	1,139	420	82,145	86,923
1984	31,742	35,692	56,930	50,998	231	273	89,176	87,887
1985	37,889	37,000	43,874	53,977	79	85	81,927	92,100
1986	19,414	38,576	51,019	53,519	130	49	70,612	93,164
1987	36,179	37,443	67,325	52,761	384	355	104,243	91,171
1988	55,716	37,478	70,943 ^d	53,835	576	528	127,763	92,225
1989	43,217	38,486	81,175 ^d	57,303	543	1,218	126,153	96,654
1990	53,504	38,911	109,778	59,792	512	394	164,188	99,639
1991	37,778	40,673	74,820	64,780	117	401	113,116	106,361
1992	46,872	39,685	82,654	66,129	1,380	367	131,273	106,632
1993	8,735	39,549	87,674	68,593	2,483	587	99,479	109,060
1994	16,211	37,105	103,343	72,619	1,937	1,139	122,630	110,793
1995	30,846	35,552	102,110	77,261	1,421	541	134,918	114,138
1996	7,419	34,847	96,413	83,084	247	1,432	105,511	119,438
1997	10,441	33,648	79,381	87,623	332	1,227	91,381	122,927
1998	17,359	31,074	81,213	88,829	210	1,434	100,216	121,641
1999	4,705	27,238	72,775	89,856	98	252	77,830	118,887
2000	444	23,387	70,825	89,016	64	105	71,438	114,054
2001	90	18,081	78,009	85,121	86	290	78,475	104,779
2002	72	14,312	80,982	85,440	288	319	81,661	101,315
2003	158	9,632	67,134	85,272	409	401	68,102	96,354
2004	2,305	8,775	97,110	83,219	691	857	100,963	93,216
2005	4,784	7,384	85,090	82,595	557	572	91,003	91,049

Table 3.13-14: Chinook Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
2006	2,777	4,778	90,085	80,893	352	444	93,658	86,658
2007	179	4,314	96,155	80,260	305	1,478	98,117	85,473
2008	8,865	3,287	98,103	81,938	420	708	108,096	86,146
2009	6,664	2,438	78,231	83,627	470	904	86,262	86,934
2010	2,731	2,634	66,056	84,172	292	354	69,433	87,780
2011	49 ^e	2,863	62,368	83,696	337	579	63,333	89,595
Avg 2001-2010	2,863	7,563	83,696	83,254	387	633	87,577	91,970

Note:

Dashes indicate no data available.

a Districts 1 and 2; also includes harvests in District 3 from 1960 to 1965; does not include personal use.

b Estimated subsistence harvest expanded from villages surveyed and estimates are reconstructed from 1990 to 2009 (Hamazaki 2011).

c Running 10-year average; does not include most recent year.

d Estimates were based on a new formula in 1988 and 1989 and are not comparable with previous years.

e An additional 699 Chinook salmon were caught during commercial periods, but were retained for personal use. These fish are included in the subsistence harvest throughout the postseason subsistence harvest survey methodology.

Source: Brazil et al. 2013; Elison et al. 2015.

Table 3.13-15: Chum Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1960	0	—	301,753 ^d	—	—	—	301,753	—
1961	0	—	179,529 ^d	—	—	—	179,529	—
1962	0	—	161,849 ^d	—	—	—	161,849	—
1963	0	—	137,649 ^d	—	—	—	137,649	—
1964	0	—	190,191 ^d	—	—	—	190,191	—
1965	0	—	250,878 ^d	—	—	—	250,878	—
1966	0	—	175,735 ^d	—	502 ^e	—	176,237	—
1967	148	—	208,445 ^d	—	338	—	208,931	—
1968	187	—	275,008 ^d	—	562	—	275,757	—
1969	7,165	—	204,105 ^d	—	384	—	211,654	—
1970	1,664	750	246,810 ^d	208,514	1,139 ^e	—	458,877	209,443
1971	68,914	916	116,391 ^d	203,020	254	—	389,495	225,155
1972	78,619	7,808	120,316 ^d	196,706	486	—	403,935	246,152
1973	148,746	15,670	179,259 ^d	192,553	675	—	536,903	270,360
1974	171,887	30,544	277,170 ^d	196,714	2,021	—	678,336	310,286
1975	184,171	47,733	176,389 ^d	205,412	1,062	—	614,767	359,100
1976	177,864	66,150	223,792 ^d	197,963	2,101	—	667,870	395,489
1977	248,721	83,937	198,355 ^d	202,769	576	129	447,781	444,652
1978	248,656	108,794	118,809 ^d	201,760	2,153	555	370,173	468,537
1979	261,874	133,641	161,239 ^d	186,140	412	259	423,784	477,979
1980	483,751	159,112	165,172 ^d	181,853	2,058	324	651,305	499,192
1981	418,677	207,320	157,306 ^d	173,689	1,793	598	578,374	518,435
1982	278,306	242,297	190,011 ^d	177,781	504	1,125	469,946	537,323
1983	276,698	262,265	146,876 ^d	184,750	1,069	922	425,565	543,924
1984	423,718	275,061	142,542 ^d	181,512	1,186	520	567,966	532,790
1985	199,478	300,244	94,750	168,049	616	150	294,994	521,753
1986	309,213	301,774	141,931 ^d	159,885	1,693	245	453,082	489,776
1987	574,336	314,909	70,709	151,699	2,302	566	647,913	468,297
1988	1,381,674	347,471	151,967 ^f	138,935	4,379	764	1,538,784	488,310
1989	749,182	460,773	139,672 ^f	142,250	2,082	2,023	892,959	605,171
1990	461,624	509,503	153,825	140,094	2,107	533	618,089	652,089

Table 3.13-15: Chum Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1991	431,802	507,291	87,237	138,959	931	378	520,348	648,767
1992	344,603	508,603	116,391	131,952	15,330	608	476,932	642,965
1993	43,337	515,233	59,797	124,590	8,451	359	111,944	643,663
1994	271,115	491,897	76,937	115,882	11,998	1,280	361,330	612,301
1995	605,918	476,636	70,977	109,322	17,473	226	694,594	591,638
1996	207,877	517,280	100,913	106,944	2,864	280	311,934	631,597
1997	17,026	507,147	37,366	102,843	790	86	55,268	617,483
1998	207,809	451,416	61,732	99,508	1,140	291	270,972	558,218
1999	23,006	334,029	44,242	90,485	562	180	67,990	431,437
2000	11,570	261,412	59,387	80,942	1,038	26	72,021	348,940
2001	1,272	216,406	56,005	71,498	1,743	112	59,132	294,333
2002	1,900	173,353	86,381	68,375	2,666	53	91,000	248,212
2003	2,764	139,083	41,167	65,374	1,713	53	45,697	209,619
2004	20,150	135,026	64,899	63,511	1,810	84	86,943	202,994
2005	69,139	109,929	58,013	62,307	4,459	500	132,111	175,555
2006	44,070	56,251	89,620	61,011	3,547	13	137,250	119,307
2007	10,763	39,871	73,603	59,881	3,237	391	87,994	101,839
2008	30,516	39,871	68,633	63,505	2,472	121	101,742	105,111
2009	76,790	21,515	43,635	64,195	2,741	285	123,451	88,188
2010	93,148	26,893	46,148	64,134	2,872	85	142,253	93,734
2011	118,256	35,051	49,242	62,499	2,289	83	169,870	96,147
Avg 2001-2010	35,051	95,820	62,810	64,379	2,726	179	9,6147	163,889

Note:

Dashes indicate no data available.

a Districts 1 and 2 only; no chum salmon harvests were reported in District 3; does not include personal use.

b Estimated subsistence harvest expanded from villages surveyed and estimates are reconstructed from 1990 to 2009 (Hamazaki 2011).

c Running 10-year average; does not include most recent year.

d Includes small numbers of small Chinook, sockeye, and coho salmon.

e Includes small numbers of sockeye salmon.

f Estimates were based on a new formula in 1988 and 1989 and are not comparable with previous years.

Source: Brazil et al. 2013; Elison et al. 2015.

Table 3.13-16: Sockeye Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1969–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1969	322	—	—	—	—	—	322	—
1970	117	—	—	—	—	—	117	—
1971	2,606	—	—	—	—	—	2,606	—
1972	102	—	—	—	—	—	102	—
1973	369	—	—	—	—	—	369	—
1974	136	—	—	—	—	—	136	—
1975	23	—	—	—	—	—	23	—
1976	2,971	—	—	—	—	—	2,971	—
1977	9,379	—	—	—	—	—	9,379	—
1978	733	—	—	—	—	—	733	—
1979	1,054	1,676	—	—	—	—	2,730	1,676
1980	360	1,749	—	—	—	—	2,109	1,917
1981	48,375	1,773	—	—	—	—	50,148	2,116
1982	33,154	6,350	—	—	—	—	39,504	6,870
1983	68,855	9,655	—	—	—	41	78,551	10,810
1984	48,575	16,504	—	—	—	—	65,079	18,628
1985	106,647	21,348	—	—	—	72	128,067	25,123
1986	95,433	32,010	—	—	—	196	127,639	37,927
1987	136,602	41,257	—	—	—	217	178,076	50,394
1988	92,025	53,979	—	—	—	291	146,295	67,264
1989	42,747	63,108	35,224	—	—	33	98,365	81,820
1990	84,870	67,277	45,897	—	—	61	113,235	91,383
1991	108,946	75,728	47,370	—	—	38	123,136	102,496
1992	92,218	81,785	43,514	—	—	131	125,430	109,795
1993	27,008	87,692	51,616	—	—	348	139,656	118,387
1994	49,365	83,507	42,362	—	—	359	126,228	124,498
1995	92,500	83,586	30,905	—	—	95	114,586	130,613
1996	33,878	82,171	40,591	—	—	315	123,077	129,265
1997	21,989	76,016	38,744	—	—	423	115,183	128,808
1998	60,906	64,555	36,103	—	—	178	100,836	122,519
1999	16,976	61,443	47,360	41,233	—	54	167,065	117,973

Table 3.13-16: Sockeye Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1969–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization ^c
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
2000	4,130	58,866	48,730	42,446	—	46	154,218	124,843
2001	84	50,792	53,245	42,729	510	231	54,070	128,942
2002	84	39,905	32,296	43,317	228	42	32,650	122,035
2003	282	30,692	32,241	42,195	0	140	32,663	112,757
2004	8,532	28,019	40,405	40,258	742	400	50,079	102,058
2005	27,645	23,936	41,589	40,062	1,062	636	70,932	94,443
2006	12,618	17,451	43,315	41,130	519	231	56,683	90,077
2007	703	15,325	47,339	41,403	488	322	48,852	83,438
2008	15,601	13,196	58,729	42,262	584	273	75,187	76,805
2009	25,673	8,666	34,941	44,525	515	162	61,291	74,240
2010	22,428	9,535	38,103	43,283	495	419	61,445	63,663
2011	13,842	11,365	39,340	42,220	380	98	53,660	53,601
Avg 2001-2010	11,365	23,752	42,220	42,117	514	271	53,601	94,846

Note:

Dashes indicate no data available.

a Districts 1 and 2 only; does not include personal use.

b Estimated subsistence harvest expanded from villages surveyed and estimates are reconstructed from 1990 to 2009 (Hamazaki 2011).

c Running 10-year average; does not include most recent year.

Source: Brazil et al. 2013; Elison et al. 2015.

Table 3.13-17: Coho Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1960	2,498	—	—	—	—	—	2,498	—
1961	5,044	—	—	—	—	—	5,044	—
1962	12,432	—	—	—	—	—	12,432	—
1963	15,660	—	—	—	—	—	15,660	—

Table 3.13-17: Coho Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1964	28,613	—	—	—	—	—	28,613	—
1965	12,191	—	—	—	—	—	12,191	—
1966	22,985	—	—	—	—	—	22,985	—
1967	56,313	—	—	—	—	—	56,313	—
1968	127,306	—	—	—	—	—	127,306	—
1969	83,765	—	—	—	—	—	83,765	—
1970	38,601	36,681	—	—	—	—	38,601	—
1971	5,253	40,291	—	—	—	—	5,253	—
1972	22,579	40,312	—	—	—	—	22,579	—
1973	130,876	41,327	—	—	—	—	130,876	—
1974	147,269	52,848	—	—	—	—	147,269	—
1975	81,945	64,714	—	—	—	—	81,945	—
1976	88,501	71,689	—	—	—	—	88,501	—
1977	241,364	78,241	—	—	—	—	241,364	—
1978	213,393	96,746	—	—	—	—	213,393	—
1979	219,060	105,355	—	—	—	—	219,060	—
1980	222,012	118,884	—	—	—	—	222,012	—
1981	211,251	137,225	—	—	—	—	211,251	—
1982	447,117	157,825	—	—	—	—	447,117	—
1983	196,287	200,279	—	—	—	1375	197,662	—
1984	623,447	206,820	—	—	—	1442	624,889	—
1985	335,606	254,438	—	—	—	136	335,742	—
1986	659,988	279,804	—	—	—	1,222	661,210	—
1987	399,467	336,953	—	—	—	1,767	401,234	—
1988	524,296	352,763	—	—	—	927	525,223	—
1989	479,856	383,853	52,917	—	—	2,459	482,315	—
1990	410,332	409,933	57,560	—	—	581	410,913	—
1991	500,935	428,765	39,252	—	—	1,003	501,938	—
1992	666,170	457,733	52,299	—	—	1,692	667,862	—
1993	610,739	479,638	28,485	—	—	980	611,719	480,899
1994	724,689	521,084	36,609	—	—	1,925	726,614	522,305

Table 3.13-17: Coho Salmon Utilization, Kuskokwim River,
Kuskokwim Management Area, 1960–2011

Year	Commercial Harvest ^a		Subsistence Harvest ^b		Test Fish Harvest	Sport Fish Harvest	Total Utilization	10-Yr Avg Utilization
	Annual	10-Yr Avg ^c	Annual	10-Yr Avg ^c				
1995	471,461	531,208	36,823	—	—	1,497	472,958	532,477
1996	937,299	544,793	43,173	—	—	3,423	940,722	546,199
1997	130,803	572,524	29,816	—	36,452	2,408	199,479	574,150
1998	210,481	545,658	24,667	—	—	2,419	237,567	553,974
1999	23,593	514,277	27,409	40,160	213	1,998	53,213	525,209
2000	261,379	468,650	45,983	37,609	2,828	1,689	311,879	482,299
2001	192,998	453,755	31,089	36,452	1,723	1,204	227,014	472,395
2002	83,463	422,961	42,602	35,635	2,484	2,030	130,579	444,903
2003	284,064	364,691	33,259	34,666	570	3,244	321,137	391,174
2004	435,407	332,023	48,898	35,143	2,259	4,996	491,560	362,116
2005	142,319	303,095	33,378	36,372	1,499	3,539	180,735	338,611
2006	185,598	270,181	41,408	36,027	1,186	1,474	229,666	309,388
2007	141,049	195,011	35,332	35,851	1,557	2,355	180,293	238,283
2008	142,862	196,035	46,463	36,403	2,984	3,755	196,064	238,283
2009	104,546	189,273	29,561	38,582	2,394	3,257	139,758	236,364
2010	58,031	197,369	32,106	38,797	1,020	1,482	92,639	232,214
2011	74,108	177,034	28,896	37,410	1,207	896	105,107	240,868
Avg 2001-2010	177,034	292,439	37,410	36,393	1,768	2,873	232,978	326,373

Note:

Dashes indicate no data available.

a Districts 1 and 2 only; does not include personal use.

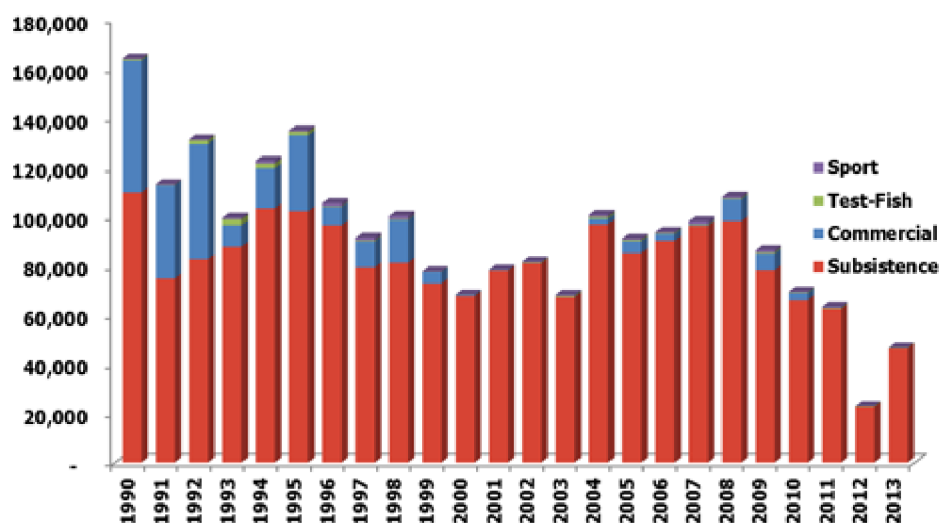
b Estimated subsistence harvest expanded from villages surveyed and estimates are reconstructed from 1990 to 2009 (Hamazaki 2011).

c Running 10-year average; does not include most recent year.

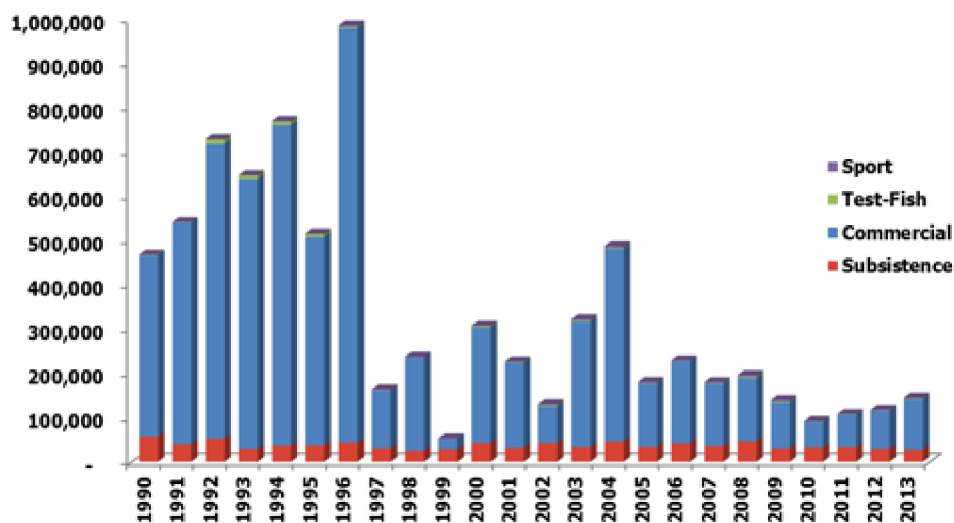
Source: Brazil et al. 2013; Elison et al. 2015.

Comparisons of annual Chinook, coho, sockeye, and chum salmon harvests for the 1990-2013 subsistence, commercial, sport fisheries are shown on Figure 3.13-3 and Figure 3.13-4. A comparison of the relative abundance of the Chinook run from 2008 to 2013 based on the catch per unit effort (CPUE) index in the Bethel test fishery is shown on Figure 3.13-5. Note the lowest CPUE since 2010 occurred in 2013.

Chinook Salmon Harvest, Kuskokwim River, 1990-2013



Coho Salmon Harvest, Kuskokwim River, 1990-2013



Source: ADFG 2015h



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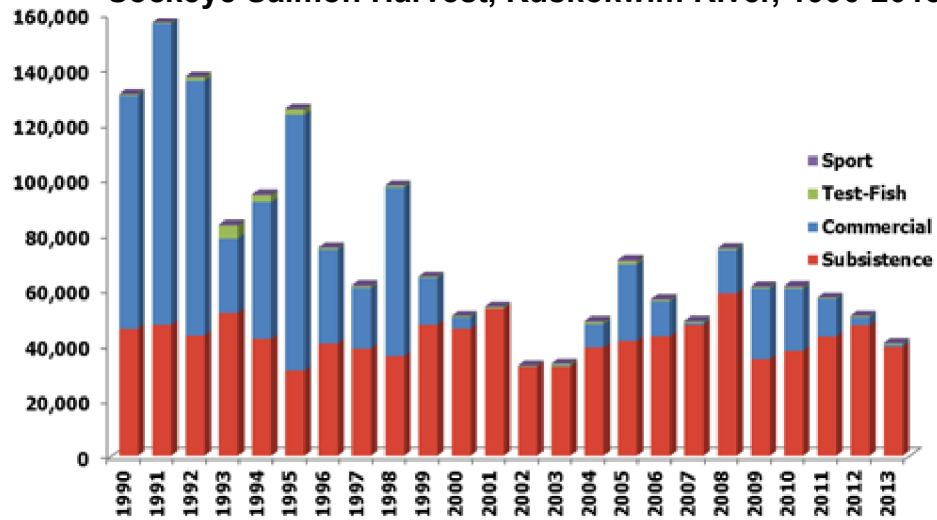


KUSKOKWIM RIVER
CHINOOK AND COHO
SALMON HARVEST, 1990-2013

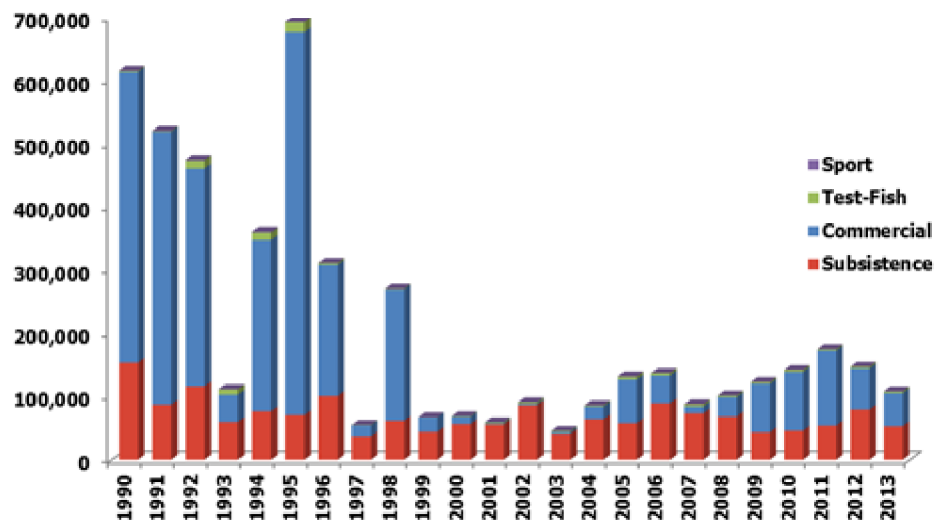
NOVEMBER 2015

FIGURE 3.13-3

Sockeye Salmon Harvest, Kuskokwim River, 1990-2013



Chum Salmon Harvest, Kuskokwim River, 1990-2013



Source: ADFG 2015h



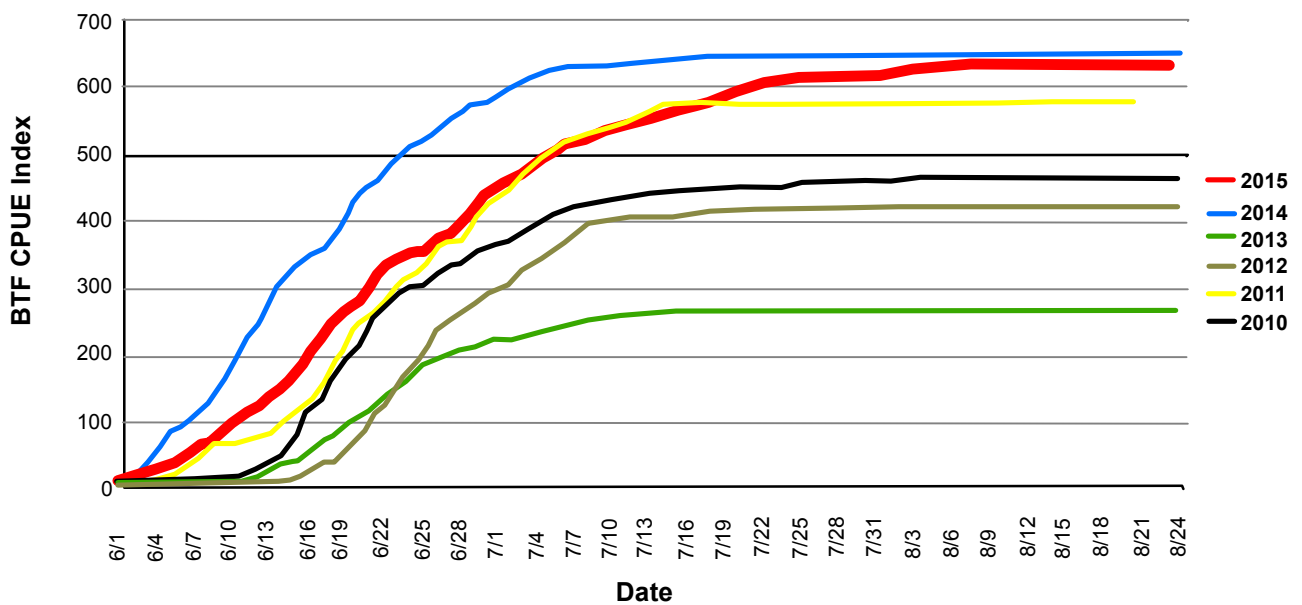
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KUSKOKWIM RIVER
CHUM AND SOCKEYE
SALMON HARVEST, 1990-2013

NOVEMBER 2015

FIGURE 3.13-4



Resulting escapement relative to New Kuskokwim River SEG (65,000 - 120,000)

2009 - Achieved (+) no restrictions
 2010 - Not Achieved (-) late tributary restrictions
 2011 - Achieved (+) 15 days restrictions, minor reduction to subsistence harvest
 2012 - Achieved (+) 35 days restrictions, significant reduction to subsistence harvest
 2013 - Not Achieved (-) tributary restrictions and late main stem restrictions, significant reduction to subsistence harvest
 2014 - Achieved (+) 30 days of restrictions, significant reduction in subsistence harvest

Data Sources: ADFG 2015i



DONLIN GOLD
PROJECT EIS



CUMULATIVE CHINOOK CPUE
IN THE BETHEL TEST FISHERY,
KUSKOKWIM RIVER, 2009-2014

NOVEMBER 2015

FIGURE 3.13-5

In 2011, estimates of the total commercial harvest were dominated by chum salmon (118,256), followed by coho (74,108), with the Chinook salmon catch limited to only 49 fish taken incidental to other catches (Brazil et al. 2013). Based on the 2012 Kuskokwim Area Management Report, final estimates of the 2011 subsistence harvest show that Chinook salmon were the most abundant species harvested (62,368), followed by chum (54,321), sockeye (43,251), and coho (32,172) salmon. The 2002-2011 total utilization average, which includes the combined Kuskokwim River harvests from the commercial, subsistence, sport, and test fisheries, included 85,621 Chinook, 109,509 chum, 54,076 sockeye, and 205,299 coho salmon (Elison et al. 2015).

Residents along the lower Kuskokwim River, where 65 percent of the area's households reside, have been responsible for 82 percent of the Chinook harvest in past years. The annual subsistence harvest of Chinook salmon has decreased 3 years in a row from a 10-year high of 98,103 fish in 2008. Measures of escapement from weirs and aerial surveys show that chum, coho, and sockeye salmon all reached their established escapement goals in 2011, but that Chinook salmon only reached escapement goals in two out of five monitored systems. Table 3.13-18 shows escapement counts from weirs in the Kuskokwim River and Bay area. Chinook escapements in the Kwethluk, Tuluksak, and George rivers were below goal and have been most years since the goals were established in 2007. Chinook salmon escapements in the Tatlawiksuk and Takotna rivers also were low compared to recent years. In the Kogruklu and Middle Fork Goodnews rivers, Chinook salmon escapements were either at or above goal. Recent years of low run abundance for Chinook salmon has caused the subsistence fishery to redirect a greater proportion of harvest efforts to other salmon and non-salmon species. As a result, non-salmon species are becoming an increasingly important component of the subsistence fishery. Annual harvest records for non-salmon species are limited making it difficult to determine the historic abundance or relative proportion these fish contribute to the subsistence fishery.

Table 3.13-18: Escapement Counts for Salmon from Kuskokwim River and Bay Area Weirs in 2011

Weir Location	Escapement Counts			
	Chinook	Sockeye	Coho	Chum
Kuskokwim River				
Kwethluk River	4,079	2,031	*	18,329
Tuluksak River	288	131	*	10,010
Aniak River	-	-	-	345,974
George River	1,571	43	30,028	44,640
Kogruklu River	6,891	8,132	24,174	76,384
Tatlawiksuk River	1,012	23	12,928	84,202
Takotna River	134	-	4,063	8,414
Telaquana River	39	35,105	138	56

Table 3.13-18: Escapement Counts for Salmon from Kuskokwim River and Bay Area Weirs in 2011

Weir Location	Escapement Counts			
	Chinook	Sockeye	Coho	Chum
Kuskokwim Bay				
Kanektok River	5,032	84,805	*	50,908
Middle Fork Goodnews River	1,861	17,946	*	19,974

Notes:

* Counts are incomplete

Source: Brazil et al. 2013

Several species of whitefish (*Coregonus* spp.) comprise an abundant and increasingly important segment of the Kuskokwim River subsistence fishery while having lesser importance to the sport and commercial fisheries of the area. The harvest of humpback whitefish comprises a large portion of the subsistence harvest in the Kuskokwim region where these fish make up about 10 percent of the total harvested weight equal to sockeye, chum, and northern pike in the village of Kwethluk and 9 percent in Akiak (Brown et al. 2013). The harvest of whitefish was largely unregulated until the 1970s when the abundance and size of these fish declined and as commercial harvests in Whitefish Lake and Johnson River were eliminated (Harper et al. 2009). Regulations on the whitefish subsistence fishery in Whitefish Lake were enacted in 1992 due to concerns of smaller fish size and abundance. Historically, this subsistence fishery relied on abundant populations of broad and humpback whitefish and few harvest restrictions. In some years, whitefish have comprised 24 percent of the non-salmon subsistence harvest caught. Whitefish are actively pursued by 87 percent of households while only 70 percent actively harvested salmon (Harper et al. 2009). Rainbow smelt also are an abundant and increasingly important component of the subsistence fishery which extends from the Bethel vicinity to above Upper Kalskag. In 2011 and 2012, peak harvests were reported at Kwethluk and Akiakchak with high catches ending near Tuluksak (Shelden et al. 2014). Coffing et al. (2001) report that 84 percent of the households in Akiachak use smelt as a subsistence resource.

The Kuskokwim River commercial fishery, which has existed since 1913, is important to local economies. In 2011, commercial harvests amounted to 205,895 salmon from the Kuskokwim River and 348,235 salmon from Kuskokwim Bay (Table 3.13-19) with most of the harvest involving chum and coho salmon (ADF&G 2013h). The Chinook salmon commercial fishery was closed in 1987 and subsequent harvest has been an incidental component of the chum and sockeye salmon commercial fishery.

Table 3.13-19: 2011 Harvest by Fishery in the Kuskokwim River and Bay

	Chinook		Sockeye		Coho		Chum		Pink	
	River	Bay	River	Bay	River	Bay	River	Bay	River	Bay
Commercial	49	15,387	13,482	38,543	74,108	189,346	118,256	104,959		
Subsistence	61,687		42,146		30,682		50,702		742	

Notes:

Numbers for subsistence fisheries are preliminary. Blank cells indicate no harvest.

Source: ADF&G 2013h.

Freshwater commercial fisheries also harvest whitefish and burbot for local markets, but this has only occurred sporadically and there has been little to no harvest in recent years. A saltwater commercial fishery exists for saffron or “tomcod,” but harvest numbers are unknown. Other species fished commercially and for subsistence include sheefish, char, Arctic grayling, northern pike, Arctic lamprey, rainbow smelt, blackfish, rainbow trout, lake trout, threespine and ninespine stickleback, and longnose sucker (ADF&G 2013h).

Kuskokwim River Sport Fishery

The ADF&G is responsible for sport fisheries management on the Kuskokwim River. Tributaries important to sport fishing include the Aniak, Tuluksak, Kisaralik, Kasigluk, Kwethluk, Holitna, and George rivers, and many smaller streams. Additionally, the Eek, Goodnews and Kanektok rivers with confluences in Kuskokwim Bay also have important sport fisheries. From 2003 to 2007, the annual sport fishing effort in the Kuskokwim River Basin was 22,563 angler days. Important sportfish species include salmon, rainbow trout, Dolly Varden, Arctic char, Arctic grayling, northern pike, and sheefish (Chythlook 2009).

Anadromous/Resident Fish and Macroinvertebrates within the Mine Access Road Corridor

Starting in 2007, fish surveys were intermittently conducted during the spring and summer in streams that would be crossed by the proposed mine access road corridor via bridges or culverts (Figure 3.13-1, and Figure 2.3-12 and Table 2.3-10 in Chapter 2, Alternatives). Many of the same species and relative abundances observed in the Crooked Creek drainage also were observed in the drainages crossed by the mine access road corridor.

Fish species observed at sampling site JJ1, located just upstream from the mouth of Jungjuk Creek, include coho salmon, Dolly Varden, Arctic grayling, round whitefish, longnose sucker, and slimy sculpin. Dolly Varden also were documented at two proposed road crossings farther upstream (crossings 61 and 63). An annual average of 4.8 adult coho salmon were observed in the mainstem Jungjuk Creek (reach JJR1) during fall aerial flights in 2007, 2008, 2010, and 2011. No fish were observed at the time of the instream surveys conducted at proposed locations for crossings 60 and 59. Crossing 60 would be situated on an unnamed tributary just upstream from its confluence with Jungjuk Creek and monitoring site JJ1. Crossing 59 would be located about a half-mile down the road corridor on an unnamed tributary about a mile upstream from its confluence with the Kuskokwim River (OtterTail 2012b).

The proposed mine access road would cross the upper reaches of Getmuna Creek near the junction of the north and south forks in the vicinity of a proposed material borrow site. As noted previously, aerial survey data suggests that Getmuna Creek is an important tributary to Crooked Creek in terms of salmon production. On average, 24 Chinook, 331 chum, and 200 coho salmon have been observed during annual aerial surveys of spawning salmon conducted along Getmuna Creek reaches from 2007 to 2011 (OtterTail 2012b). Additionally, an unnamed tributary would be crossed (#49) by the proposed mine access road near the South Fork of Getmuna Creek where coho salmon, Dolly Varden, Arctic grayling, and slimy sculpin were collected. No fish were collected or observed at crossing 43, located at an unnamed tributary north of the North Fork of Getmuna Creek.

Macroinvertebrate inventories were conducted within the drainages influenced by the proposed mine access road corridor to characterize species presence and community structure as a basis for assessing potential impacts of the proposed project. The macroinvertebrate communities observed from the sites sampled are similar to those found in the Crooked Creek drainage and other systems throughout Alaska (OtterTail 2012b). In general, the observed macroinvertebrate taxa are indicative of good water quality. However, as observed in Crooked Creek sites, metrics such as the Shannon Diversity Index (H) and evenness (e) suggested that natural stressors occur in the system. Freezing, flooding, and high natural siltation rates are likely the most important factors affecting stream community structure in Kuskokwim River tributaries. Siltation limits macroinvertebrate colonization by filling the interstitial spaces in the gravel-cobble stream bottom, reducing the amount of area in the stream bottom available for colonization. Furthermore, these interstitial spaces are used by macroinvertebrates as refugia from freezing during winter. Reductions in the availability of such interstitial spaces would, therefore, tend to prevent macroinvertebrates from successfully overwintering and maintaining a sustainable community structure.

As shown in Figure 2.3-42 (Chapter 2, Alternatives), the proposed 73-mile long road that would connect the BTC Port site to the mine would be about 43 miles (2.5 times) longer than the 30-mile long road that would connect the Angyaruaq (Jungjuk) Port site with the mine under Alternative 2. The proposed road from the BTC Port site would cross 40 streams, 11 fewer than the number crossed for Alternative 2 (Table 2.3-38, Chapter 2, Alternatives). Of the streams crossed, 8 would involve bridges while 32 would involve culverts (Alternative 2 would require 5 bridges and 45 culverts). Bridge crossings would occur at Ones Creek, Kaina Creek, Owhat River, Jubil Creek, Tyrel Creek, Cobalt Creek, Iditarod River, and Crooked Creek. Many of these waters, including the lower reaches of their tributaries, are used by anadromous and resident fishes for spawning and rearing life stages and are classified as EFH under the Magnuson-Stevens Act. Anadromous species occurring in the waters crossed by the roadway include Chinook, coho, and chum salmon.

3.13.2.2.3 ESSENTIAL FISH HABITAT

Similar to the mine site area, the river and mine access road transportation corridors include river and stream segments that are designated as EFH for the Alaska stocks of Pacific salmon. Aquatic habitats these fish rely on in these waters constitute EFH and are protected under the Magnuson-Stevens Act. Designated EFH waters along the mine access road corridor within the Crooked Creek watershed include Crooked, Jungjuk, and Getmuna creeks and their respective tributaries. Designated EFH also exists from Kuskokwim Bay upriver beyond the proposed

Angyaruaq (Jungjuk) Port site and mouth of Crooked Creek. The Kuskokwim River, which would serve as the key waterway for barge traffic delivering fuel and freight for the proposed project, supports all five Pacific salmon species (i.e., Chinook, chum, coho, pink, and sockeye salmon). These species utilize the Kuskokwim River primarily as a migration corridor between Kuskokwim Bay and tributaries located at various distances upriver and downriver of the proposed Angyaruaq (Jungjuk) Port site. While spawning and juvenile rearing habitats for these salmon species have been documented within Kuskokwim River tributaries, substantial spawning or juvenile rearing has not been documented by ADF&G within the mainstem of the Kuskokwim River from Kuskokwim Bay to the proposed Angyaruaq (Jungjuk) Port site (Johnson and Daigneault 2013).

Under Alternative 4, many of the drainages crossed by the mine access road originating from the BTC Port site are used by anadromous and resident fishes for rearing and spawning and are classified as EFH under the Magnuson-Stevens Act. Appendix Q contains the Draft Essential Fish Habitat Assessment, which includes an assessment of potential effects on these resources.

3.13.2.2.4 FISH TISSUE METALS ANALYSIS

From 2010 to 2011, the BLM, in cooperation with FWS and ADF&G, investigated mercury, arsenic, and antimony concentrations in tissue samples collected from fish and aquatic insects in the Central Kuskokwim River area from McGrath to Aniak (which includes river segments that would be traveled by barge traffic for the proposed project). Sites sampled during the 2010-2011 study, and during 2005-2007 studies that targeted northern pike, involved the mainstem Kuskokwim and several large and small tributaries upstream and downstream from Crooked Creek (Matz 2012, 2014). In the 2010-2011 study, resident fish species (slimy sculpin, juvenile Dolly Varden, and juvenile Arctic grayling) were sampled from small tributaries associated with abandoned mines (Red Devil Creek and Cinnabar Creek) located upstream from the Crooked Creek confluence. Other resident fish species, including Arctic grayling, northern pike, sheefish, and burbot, also were collected and sampled from large tributaries and the mainstem river up and downriver from Crooked Creek. As described below, results from these studies illustrate that many natural mercury deposits and historic mine sites have contributed to mercury levels in the Kuskokwim watershed, including the lower Kuskokwim mainstem and certain tributaries, with variable levels of mercury and MeHg being documented in certain species of resident fish and aquatic biota (Matz 2012).

Mercury

Results of BLM's 2010-2011 investigation showed differences among species with respect to mercury concentrations. Burbot and northern pike had the highest average total mercury concentrations in muscle tissue (0.45 and 0.42 micrograms per gram [$\mu\text{g/g}$], respectively). Sheefish, adult Arctic grayling, slimy sculpin, and juvenile Dolly Varden had lower concentrations (0.20-0.22 $\mu\text{g/g}$). Adult Dolly Varden, juvenile Arctic grayling, and long-nosed sucker had the lowest concentrations (0.05, 0.04, and 0.02 $\mu\text{g/g}$, respectively). Seasonal data from burbot show substantially higher mercury concentrations in the summer/fall (0.45 $\mu\text{g/g}$) than in the winter (0.16 $\mu\text{g/g}$). This is likely a result of sampling from populations with different life histories.

Ratios of methyl mercury to total mercury were approximately 1:1 in tissues of northern pike, burbot, sheefish, and Arctic grayling. This suggests that these fish are experiencing chronic,

long-term exposure to mercury through their diet rather than from direct acute exposure. Slimy sculpin and juvenile Dolly Varden exhibited lower ratios, suggesting exposure through gill or digestive tissue.

With regard to fish length and age, total mercury in whole body slimy sculpin was found to be significantly and positively correlated with length but not for juvenile Dolly Varden or Arctic grayling. Muscle concentrations of total mercury in northern pike were significantly and positively correlated with age and length; however, this was not observed for burbot, sheefish, or Arctic grayling.

Spatial variations accounted for some key differences in mercury concentrations with slimy sculpin, Dolly Varden, and aquatic insects sampled from Red Devil Creek and Cinnabar Creek having had significantly higher concentrations of total mercury than their counterparts collected from other sampled tributaries. This suggests that historic mine activities along those creeks have influenced mercury concentrations in fish and aquatic insect populations. These results agree with findings from Gray et al. (2000), who observed similar patterns. Northern pike, burbot, and Arctic grayling in the George River had significantly higher mercury concentrations than in other large tributaries, however, sheefish showed no significant differences in mercury concentrations among the sampled rivers. Based on the study findings relative to mercury concentrations in fish, it was recommended that the State of Alaska issue consumption guidance for northern pike and burbot from the Central Kuskokwim River area since these species are harvested for subsistence use.

Arsenic and Antimony

Arsenic concentrations were determined to be highest in aquatic insects (mean concentrations of 12 mg/kg) as compared to other biota. Among fish sampled, sheefish, burbot, juvenile Dolly Varden, and slimy sculpin had the highest arsenic concentrations (1.3–3.1 mg/kg). Adult Dolly Varden, northern pike, long-nosed sucker, and juvenile Arctic grayling had considerably lower concentrations (0.12–0.38 mg/kg) with adult Arctic grayling showing the lowest concentrations (0.03 mg/kg). With regard to spatial variation, arsenic concentrations were highest in biota from Red Devil Creek. Arsenic concentrations in burbot were found to decline in fish collected in upstream portions of drainages compared to downstream reaches. Differences in arsenic concentrations relative to spatial variation were not observed for sheefish or northern pike.

Antimony was not detected in many sampled fish, but it was detected in 100 percent of the aquatic insects sampled. The mean concentration of antimony was two orders of magnitude higher in Red Devil Creek insects than in insects collected from other tributaries.

Preliminary data from ongoing ADF&G radio-telemetry research conducted in 2012 and 2013 have revealed information that should provide future insights concerning relationships between tissue metal concentrations and the distributions of resident fish in the Kuskokwim River and its tributaries (Albert 2013). Based on preliminary study results, most of the Arctic grayling radio-tagged in the George River were found to remain within this drainage throughout the study period. Arctic grayling tagged near Sleetmute, however, moved to the Stony River to overwinter where they spawned during the following summer. These fish later migrated downstream to the Oskawalik, George, and Holokuk rivers. During this same study, most northern pike radio-tagged in the George River remained within the drainage, as did most of the northern pike tagged in the Holitna River. Northern pike tagged between the George and Holitna rivers migrated into the Holitna during the winter. Subsequently, these fish returned to

the same areas where they were tagged along the mainstem Kuskokwim River. This suggests that elevated mercury concentrations in tissues from fish known to remain in the George River drainage may be associated with mercury exposure from processes occurring in this drainage. Movement patterns of radio-tagged burbot showed these fish migrated upstream between mid-September and December (most likely for spawning) and returned downstream between February and May. They remained in the middle and lower sections of the mainstem Kuskokwim River between Crooked Creek and Bethel. Their residency in these waters suggests these fish would be susceptible to long-term exposure of metal concentrations in the river as may be verified from future tissue analysis results.

3.13.2.3 PIPELINE ROUTE

The following information is specific to the proposed buried natural gas pipeline that would extend about 315 miles north and west from the west end of the Beluga Gas Field near Cook Inlet to the proposed mine site (Figure 2.3-14, Chapter 2, Alternatives). The proposed pipeline would connect with the existing Beluga Natural Gas Pipeline about 8.5 miles west of Beluga (Figure 2.3-14). Natural gas from the pipeline would be used to provide fuel for the power plant for generating electricity, providing heat, and processing ore from the proposed mine (Figure 2.3-1, Chapter 2, Alternatives). As described in greater detail in Section 3.5, Surface Water Hydrology, 452 streams involving several major drainages would be crossed along the 100-foot-wide temporary construction corridor that would extend west from Cook Inlet, across the Alaska Range near MP 118, to the Alaska Interior Region (Table 3, Appendix G). Of these streams, 163 have been identified as fish bearing with nearly half (72) supporting one or more species of salmon. Besides the pipeline, temporary shoofly and pipeline access roads would be constructed within the proposed pipeline corridor. Near water body crossings, temporary roads would be installed close to the pipeline to provide construction access.

3.13.2.3.1 AQUATIC HABITAT

The proposed pipeline route begins near the settlement of Beluga on the north end of Cook Inlet and extends northwest towards the headwaters of the Skwentna River. The route then enters the Alaska Range and crosses the divide near MP 118. Once in the Kuskokwim River drainage, the route continues northwest following the South Fork of the Kuskokwim River. After exiting the Alaska Range near MP 150, the route turns to the west/southwest and proceeds another 163 miles ending at Donlin Creek at MP 315. The route passes through varied topography with elevations ranging from just above sea level to approximately 3,350 feet near the summit of Rainy Pass.

The proposed pipeline route crosses drainages ranging in size from small headwater streams to large glacially fed rivers. Stream crossings occur in four major drainages: Cook Inlet, and the Yentna, Skwentna, and Kuskokwim rivers. In 2010, data associated with stream channel characteristics, water quality, and stream substrates were collected at 233 sampling sites within these drainages as summarized below (Table 3.13-20).

Cook Inlet Drainages

The average wetted width for the 131 crossings within the Cook Inlet drainage was 6.8 feet (range: 0 to 95 feet). In general, surveyed streams had sand/silt/clay as a dominant substrate

and gravel as the sub-dominant substrate type. The average pH for the drainage was 6.9 (range: 5.5 to 7.9) and the average water temperature over the period sampled was 46.3°F (range: 36.5 to 58.4°F). The average conductivity was 45.2 micro Siemens per centimeter ($\mu\text{S}/\text{cm}$) with a range of 16 to 105 $\mu\text{S}/\text{cm}$.

Skwentna River Drainage

The average wetted width for the 105 crossings within the Skwentna River drainage was 40.8 feet (range: 0 to 1,850 feet). In general, silt/sand/clay was the dominant substrate and gravel was the sub-dominant substrate type. The average pH for the drainage was 7.1 (range: 5.6 to 9.6) and the average water temperature for the period sampled was 49.8°F (range: 37.9 to 61.8°F). The average conductivity was 109.6 $\mu\text{S}/\text{cm}$ with a range of 12 to 385 $\mu\text{S}/\text{cm}$.

Yentna River Drainage

The average wetted width for the six crossings within the Yentna River drainage was 2.5 feet (range: 2 to 3 feet). In general, these streams had sand/silt/clay as a dominant substrate and gravel as the sub-dominant substrate type. The observed substrate conditions may not be representative of the overall drainage given the small sample size. The average pH at these sites was 7.0 and the average water temperature for the period sampled was 51.4°F (range: 47.1 to 58°F). The average conductivity was 53.3 $\mu\text{S}/\text{cm}$ with a range of 28 to 77 $\mu\text{S}/\text{cm}$.

Kuskokwim River Drainage

Stream characteristics and water quality data were collected at 210 crossings within the Kuskokwim River drainage. The relatively large geographical size of this drainage resulted in the most variation in stream characteristics. The average wetted width for sampling sites was 66.6 feet (range: 0 to 2,000 feet). In general, streams sampled within the Kuskokwim River drainage had sand/silt/clay as a dominant substrate and gravel as the subdominant substrate type. The average pH at these sites was 7.4 (range: 2 to 9.2) and average water temperature for the period sampled was 43.0°F (range: 34.1 to 59°F). The average conductivity was 221.0 $\mu\text{S}/\text{cm}$ (range: 9.1 to 942 $\mu\text{S}/\text{cm}$). The broad range of conductivity may have resulted from the varied geological conditions in the drainage.

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Table 3.13-20: Stream Characteristics and Water Quality Data by Drainage for the Pipeline Route (2010)

Drainage Area	Mainstem	Tributary	# Sites	Wetted Width (ft)		Substrate		pH		Conductivity (µS/cm)		Water Temp (°F)		Water Temp (°C)	
				AVG	Range	Average (%) Dominant Type	Average (%) Sub-Dominant Type	AVG	Range	AVG	Range	AVG	Range	AVG	Range
Cook Inlet	Beluga R.		1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Theodore R.	Mainstem	1	10.0	N/A	N/A	N/A	6.7	N/A	74.0	N/A	51.0	N/A	10.6	N/A
		Tributaries	2	8.5	(5-12)	(60) Sand/Silt/Clay	(40) Org. Other	6.5	(6.2-6.8)	46.2	(36.4-56)	53.1	(50.1-56.1)	11.7	(10.1-13.4)
	Lewis R.	Tributaries	42	9.8	(1-95)	(21) Sand/Silt/Clay	(10) Gravel	6.9	(6.1-7.5)	35.2	(22.1-68)	44.8	(36.5-51.8)	7.1	(2.5-11)
	Alexander Cr.	Lower Sucker Cr.	48	5.7	(0-16)	(16) Sand/Silt/Clay	(14) Gravel	7.1	(6.1-7.9)	39.3	(16.5-66.8)	45.0	(39.4-51.1)	7.2	(4.1-10.6)
		Bear Cr.	17	6.4	(0-20)	(22) Gravel	(17) Sand/Silt/Clay	6.9	(5.5-7.6)	49.0	(30.2-87.7)	47.1	(42.4-50.9)	8.4	(5.8-10.5)
		Clear Cr.	18	4.7	(1-13)	(28) Gravel	(24) Sand/Silt/Clay	6.8	(5.9-7.6)	56.7	(33-93)	47.4	(41.9-57.2)	8.5	(5.5-14)
		Deep Cr.	2	7.0	(5-9)	(45) Cobble	(34) Gravel	6.7	(6.7-6.8)	92.9	(81-104.8)	53.8	(49.1-58.4)	12.1	(9.5-14.7)
Cook Inlet Total:			131	6.8	(0-95)	(19) Sand/Silt/Clay	(16) Gravel	6.9	(5.5-7.9)	45.2	(16.5-104.8)	46.3	(36.5-58.4)	7.9	(2.5-14.7)
Skwentna	Skwentna R.	Mainstem	3	1025.0	(200-1850)	(45) Sand/Silt/Clay	(43) Gravel	6.8	(6.8-6.8)	158.0	(158-158)	50.8	(50.8-50.8)	10.4	(10.4-10.4)
	Eightmile Cr.	Mainstem	2	12.0	(12-12)	(48) Sand/Silt/Clay	(5) Org. Other	7.3	(7.3-7.3)	78.7	(78.7-78.7)	61.8	(61.8-61.8)	16.6	(16.6-16.6)
		Tributaries	5	4.7	(2-7)	(25) Cobble	(11) Gravel	7.2	(7.2-7.2)	72.0	(67.7-76.4)	48.0	(47.5-48.4)	8.9	(8.6-9.1)
	Shell Cr.	Mainstem	1	25.0	N/A	(70) Gravel	(20) Sand/Silt/Clay	6.3	N/A	40.0	N/A	56.4	N/A	13.6	N/A
		Tributaries	5	4.0	(4-4)	(16) Boulder/Bedrock	(10) Sand/Silt/Clay	6.2	(6.2-6.2)	30.0	(30-30)	56.7	(56.7-56.7)	13.7	(13.7-13.7)
	Happy R.	Mainstem	2	157.5	(150-165)	(58) Cobble	(33) Gravel	8.1	(6.6-9.6)	286.5	(248-325)	44.1	(44-44.2)	6.7	(6.7-6.8)
		Canyon Cr.	10	6.0	(0-35)	(50) Sand/Silt/Clay	(7) Cobble	6.7	(6.6-6.9)	206.3	(138-240)	41.2	(38.3-45.8)	5.1	(3.5-7.7)
		Squaw Cr.	3	12.5	(5-20)	(25) Gravel	(25) Gravel	7.0	(6.7-7.3)	175.5	(168-183)	44.6	(42.5-46.8)	7.0	(5.8-8.2)
		Indian Cr.	3	22.0	(18-26)	(25) Gravel	(20) Cobble	7.4	(6.9-7.8)	258.5	(243-274)	42.0	(41.2-42.8)	5.6	(5.1-6)
		Pass Cr.	4	30.7	(20-47)	(39) Cobble	(34) Gravel	7.6	(6.9-8.3)	315.0	(242-385)	39.9	(37.9-42)	4.4	(3.3-5.6)
		Tributaries	10	9.8	(0-28)	(62) Sand/Silt/Clay	(14) Gravel	7.1	(6.1-8.7)	158.8	(12-315)	46.7	(40.6-51.1)	8.1	(4.8-10.6)
		Tributaries		57	5.7	(0-19)	(28) Sand/Silt/Clay	(18) Gravel	7.1	(5.6-8.4)	42.2	(18.1-170)	53.7	(45.4-61.7)	12.0
	Skwentna Total:			105	40.8	(0-1850)	(30) Sand/Silt/Clay	(18) Gravel	7.1	(5.6-9.6)	109.6	(12-385)	49.8	(37.9-61.8)	9.9
Yentna	Yentna R.	Johnson Cr.	6	2.5	(2-3)	(38) Sand/Silt/Clay	(5) Gravel	7.0	(6.7-7.6)	53.3	(28-77)	51.4	(47.1-58)	10.8	(8.4-14.4)
Yentna Total:			6	2.5	(2-3)	(38) Sand/Silt/Clay	(5) Gravel	7.0	(6.7-7.6)	53.3	(28-77)	51.4	(47.1-58)	10.8	(8.4-14.4)
Kuskokwim	S.F. Kuskokwim R.	Mainstem	1	2000.0	N/A	(60) Cobble	(20) Gravel	8.6	N/A	435.0	N/A	42.8	N/A	6.0	N/A
		Tatina R.	20	83.8	(3-850)	(37) Cobble	(26) Gravel	8.6	(7.3-9)	326.3	(192-407)	43.2	(39-52)	6.2	(3.9-11.1)
		Post R.	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		High Lakes	1	2.0	N/A	(70) Org. Macro	(30) Sand/Silt/Clay	7.0	N/A	269.0	N/A	44.1	N/A	6.7	N/A
		Tin Cr.	4	10.0	(10-10)	(20) Gravel	(15) Cobble	7.2	(7.2-7.2)	524.0	(524-524)	42.3	(42.3-42.3)	5.7	(5.7-5.7)
		Sheep Cr.	15	14.0	(4-35)	(25) Sand/Silt/Clay	(15) Gravel	7.8	(7.4-8.9)	800.7	(702-864)	46.0	(44.1-47.9)	7.8	(6.7-8.8)
		Tributaries	17	11.3	(2-50)	(21) Sand/Silt/Clay	(15) Gravel	8.0	(6.7-8.9)	653.7	(497-766)	45.9	(40.1-59)	7.7	(4.5-15)

Table 3.13-20: Stream Characteristics and Water Quality Data by Drainage for the Pipeline Route (2010)

Drainage Area	Mainstem	Tributary	# Sites	Wetted Width (ft)		Substrate		pH		Conductivity (µS/cm)		Water Temp (°F)		Water Temp (°C)	
				AVG	Range	Average (%) Dominant Type	Average (%) Sub-Dominant Type	AVG	Range	AVG	Range	AVG	Range	AVG	Range
Kuskokwim (cont'd)	Windy F. Kuskokwim R.	Mainstem	1	1000.0	N/A	(40) Sand/Silt/Clay	(35) Cobble	7.2	N/A	443.0	N/A	49.2	N/A	9.6	N/A
		Pitka F.	2	2.0	(2-2)	N/A	N/A	9.0	(9-9)	N/A	N/A	42.5	N/A	5.8	(5.8-5.8)
		Khuchaynik Cr.	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Tributaries	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	M.F. Kuskokwim R.	Mainstem	1	120.0	N/A	(60) Cobble	(20) Gravel	8.7	N/A	501.0	N/A	52.6	N/A	11.4	N/A
		Tributaries	21	11.6	(0-45)	(38) Sand/Silt/Clay	(21) Gravel	8.6	(6.9-9.1)	427.5	(32-942)	46.0	(38.6-54.4)	7.8	(3.7-12.4)
	Big R.	Mainstem	1	180.0	N/A	(70) Cobble	(20) Sand/Silt/Clay	7.2	N/A	393.0	N/A	46.4	N/A	8.0	N/A
		Sidearm	4	25.5	(16-35)	(44) Sand/Silt/Clay	(18) Gravel	6.9	(6.7-7.2)	385.5	(382-389)	45.4	(43.6-47.2)	7.4	(6.4-8.4)
		Tributaries	17	1.7	(0-4)	(42) Sand/Silt/Clay	(14) Org. Other	7.4	(5.7-8.8)	187.2	(29-270)	48.3	(38.2-57.6)	9.1	(3.4-14.2)
	Tatlawiksuk R.	Mainstem	1	192.0	N/A	(60) Gravel	(20) Cobble	8.4	N/A	127.0	N/A	43.6	N/A	6.4	N/A
		Sidearm	2	16.0	(16-16)	(70) Sand/Silt/Clay	(18) Gravel	7.9	(7.9-7.9)	142.0	(142-142)	40.3	(40.3-40.3)	4.6	(4.6-4.6)
		Tributaries	42	9.1	(2-67)	(48) Sand/Silt/Clay	(13) Gravel	7.1	(4.4-9.2)	57.4	(9.1-242)	41.6	(36.6-55.5)	5.3	(2.6-13.1)
	Kuskokwim R.	Mainstem	1	1500.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Sidearm	1	900.0	N/A	(80) Sand/Silt/Clay	(20) Gravel	N/A	N/A	365.0	N/A	49.1	N/A	9.5	N/A
	Nunsatuk R.	Tributaries	3	2.5	(2-3)	(72) Sand/Silt/Clay	(10) Cobble	7.3	(6.1-8.5)	145.5	(130-161)	39.0	(38.9-39)	3.9	(3.8-3.9)
	Moose Cr.	Mainstem	1	6.0	N/A	(50) Sand/Silt/Clay	(20) Cobble	6.2	N/A	105.0	N/A	39.6	N/A	4.2	N/A
		Tributaries	1	2.0	N/A	(80) Sand/Silt/Clay	(10) Gravel	3.6	N/A	137.0	N/A	35.3	N/A	1.8	N/A
	George R.	Mainstem	2	100.0	(100-100)	(30) Cobble	(10) Gravel	6.8	(6.8-6.8)	172.0	(172-172)	N/A	(0-0)	N/A	N/A
		E.F. George R.	13	18.8	(1-120)	(47) Sand/Silt/Clay	(23) Gravel	6.9	(2-8.5)	154.0	(97-205)	38.5	(36.5-40.2)	3.6	(2.5-4.6)
		N.F. George R.	3	34.0	(3-65)	(32) Gravel	(25) Cobble	7.9	(7-8.9)	215.0	(197-233)	37.5	(34.1-41)	3.1	(1.2-5)
		Tributaries	3	2.5	(2-3)	(80) Sand/Silt/Clay	(23) Org. Other	6.7	(6.5-6.8)	138.0	(138-138)	38.8	(38.2-39.4)	3.8	(3.4-4.1)
	Tributaries		23	17.5	(2-150)	(49) Sand/Silt/Clay	(13) Org. Other	7.1	(6.4-8.6)	101.2	(50-248)	40.8	(36.5-48.8)	4.9	(2.5-9.3)
Kuskokwim Total:			210	66.6	(0-2000)	(36) Sand/Silt/Clay	(15) Gravel	7.4	(2-9.2)	221.0	(9.1-942)	43.0	(34.1-59)	6.1	(1.2-15)
Grand Total:			452	43.0	(0-2000)	(30) Sand/Silt/Clay	(16) Gravel	7.2	(2-9.6)	140.3	(9.1-942)	45.7	(34.1-61.8)	7.6	(1.2-16.6)

Notes:
Table represents averaged stream data along the proposed pipeline collected during summer, 2010. Substrate displayed as (percentage) of substrate type within survey reach.
N/A = not applicable
Source: OtterTail 2012e.

3.13.2.3.2 FISH

Lakes, rivers, and perennial and intermittent streams along the proposed pipeline route provide seasonal or year-round fish habitats supporting spawning, foraging, rearing, refuge, and/or migratory use. Some streams intersected by the proposed pipeline route are likely to provide habitat for resident and/or anadromous fishes, including fish of conservation concern as identified in Alaska's Comprehensive Wildlife Conservation Strategy (e.g., ninespine stickleback, Pacific lamprey, and others) (ADF&G 2006c). Anadromous fish present in the proposed project area include all five species of Pacific salmon: Chinook, chum, coho, pink, and sockeye (OtterTail 2012a). Streams along the proposed pipeline route also provide habitat to native fish (e.g., slimy sculpin, longnose sucker, stickleback [spp.], and rainbow smelt). These species play a crucial role in the aquatic ecosystem as they provide prey for terrestrial animals and other freshwater and anadromous fishes (ADF&G 2006c; Groot and Margolis 1991). A summary of stream crossings along the five drainages traversed by the proposed pipeline route is provided in Table 3.13-21. A summary of fish species known to occur in drainages along the proposed pipeline route is presented in Table 3.13-22 and Table 3.13-23.

Of the streams along the proposed route, those located in the Kuskokwim and Skwentna river drainages support the largest number of fish species (20 and 13 species, respectively). The mainstem of the Kuskokwim River and the East Fork of the George River are the most diverse of these drainages. Streams in the Cook Inlet and Yentna drainages are also intersected by the proposed route but provide habitat to fewer fish species (12 and 5 species, respectively). The two most common species found across all drainages were slimy sculpin and Dolly Varden (Table 3.13-22 and Table 3.13-23).

In 2010 and 2011, a total of 452 stream crossings were identified along the proposed pipeline route. Of these, 131 are located within the Cook Inlet drainage, 105 are within the Skwentna drainage, 6 are within the Yentna drainage, and 210 are within the Kuskokwim drainage. Crossings are defined as the exact location the route crosses a stream. Not all sampling sites were located at a crossing.

A total of 845 sampling site visits were conducted to assess fish populations. Fish presence was documented at 163 of the 452 crossings sampled. Of 163 crossings with fish, 38 crossings occur within reaches previously documented as containing anadromous fish by ADF&G's Anadromous Waters Catalog (Johnson and Daigneault 2013) and were not sampled. In addition, salmon were documented at 34 crossings not previously identified by ADF&G and will be candidates for ADF&G's updated Anadromous Waters Catalog, and subsequently subject to the Department's permitting requirements. A total of 8,960 fish were collected in all sites surveyed with the total number of fish captured by drainage ranging from 408 fish in the Yentna River drainage to 4,585 fish in the Kuskokwim River drainage (OtterTail 2012a).

Salmon species accounted for approximately 17 percent of the total fish captured in sites surveyed along the proposed pipeline route in 2010 and 2011. Of the 1,554 juvenile salmon observed, 885 and 536 were captured in the Skwentna and Kuskokwim river drainages, respectively. Only 109 and 24 salmon were collected in the Cook Inlet and Yentna drainages, respectively (OtterTail 2012a). Coho salmon constituted approximately 86 percent of the total salmon captured across all drainages, while Chinook salmon accounted for 10 percent. Captures of juvenile chum and sockeye salmon were rare (OtterTail 2012a).

Cook Inlet Drainage

A total of 2,447 fish were collected at 82 fish sampling sites in these drainages. Salmon were documented at two crossings by electrofishing or by documentation of salmon at an upstream sampling site. Fish species collected in the Cook Inlet drainages included coho salmon, Dolly Varden, rainbow trout, nine-spine stickleback, three-spine stickleback, slimy sculpin, and lamprey. Additionally, ADF&G has previously documented the presence of Chinook salmon, humpback whitefish, and coastrange sculpin in drainages that would be crossed by the proposed pipeline (Table 3.13-22 and Table 3.13-23).

Skwentna River Drainage

A total of 59 sampling sites were surveyed for fish within the Skwentna River drainage resulting in the collection of 1,520 fish. Salmon were documented at 12 crossings by electrofishing or by documentation of salmon at an upstream sampling site. Fish species collected in the Skwentna drainage area included coho salmon, Chinook salmon, sockeye salmon, Arctic grayling, Dolly Varden, rainbow trout, Alaskan brook lamprey, burbot, nine-spine stickleback, three-spine stickleback, and slimy sculpin. ADF&G also previously documented pink salmon within drainages that would be crossed by the proposed pipeline (Table 3.13-22 and Table 3.13-23).

Yentna River Drainage

A total of 408 fish were collected within the four fish sampling sites in the Yentna River drainage. Coho salmon were documented at a single sampling site by electrofishing. The fish species collected in the Yentna drainage included coho salmon, rainbow trout, longnose sucker, three-spine stickleback, and slimy sculpin (Table 3.13-22 and Table 3.13-23).

Kuskokwim River Drainage

A total of 185 sampling sites were surveyed for fish within the Kuskokwim River drainage resulting in a total of 4,585 fish. Salmon were documented at 19 crossings by electrofishing or by documentation of salmon at an upstream sampling site. The fish species collected in the Kuskokwim drainage included coho salmon, Chinook salmon, Arctic grayling, Dolly Varden, round whitefish, Alaska blackfish, longnose sucker, northern pike, and slimy sculpin. ADF&G has previously documented chum salmon, sockeye salmon, rainbow trout, broad whitefish, sheefish, lake chub, Alaskan brook lamprey, burbot, and ninespine stickleback, within drainages that would be crossed by the proposed pipeline (Table 3.13-22 and Table 3.13-23).

The greatest number of fish captured occurred in the Kuskokwim River drainage. Overall, the highest catch per unit of effort (0.039 fish/second of electrofishing) also occurred in the Kuskokwim River drainage with the lowest catch per unit of effort occurring in the Yentna River drainage (0.000 fish/sec). By comparison, the catch per unit effort in the Skwentna River was 0.019 fish/sec while the Cook Inlet drainage had a catch per unit of effort rate of 0.021 fish/sec (OtterTail 2012a).

In addition to electrofishing, aerial surveys were conducted to assess the distribution and relative abundance of adult salmon populations (OtterTail 2012a). Aerial surveys were conducted on 45 reaches. Of these, 12 were in the Cook Inlet drainage, 9 were in the Skwentna River drainage, 1 was in the Yentna River drainage, and 23 were in the Kuskokwim River

drainage. A total of 101 Chinook, 41 chum, 46 coho, and 801 sockeye salmon adults were observed during the surveys. These values do not represent the total spawning escapement in these drainages since survey flights generally focused on identifying spawning habitat locations and the presence/absence of adult salmon rather than determining population estimates.

3.13.2.3.3 ESSENTIAL FISH HABITAT

Rivers and tributaries with variable substrate character would be crossed by the proposed pipeline, temporary access roads, and shoofly roads within the Kuskokwim, Skwentna, Yentna, and Cook Inlet drainages (Table 3.13-20 and Table 3.13-21). Table 3.13-22 lists the rivers and tributaries documented as supporting EFH-protected species that the proposed pipeline route would cross (OtterTail 2012a, 2014b). Pacific salmon EFH has been designated within 23 mainstem and tributary streams in all 4 of the main drainages, where substantial levels of spawning and rearing have been documented (Johnson and Daigneault 2013). Drainages crossed by the proposed pipeline route have salmon spawning runs that extend from May, when Chinook salmon start their upstream migrations, through September when coho salmon spawn throughout area streams. These include Lewis River and Wolverine and Sucker creeks that are of particular importance to salmon. The Lewis River has historic stocks of Chinook and coho salmon with Chinook now recognized as a species of concern by the ADF&G Board of Fish. Below the confluence of Wolverine Creek, Wolverine and Sucker creeks provide over 90 percent of the spawning habitat for Chinook salmon in the Alexander Creek drainage. EFH for all five salmon species has been designated in Cook Inlet, with most species present in the Beluga and Theodore rivers and within the Skwentna River drainage's mainstem and Shell Creek. EFH for Chinook, coho, chum, and pink salmon has been designated in the upper Kuskokwim drainages, while only coho EFH is present in the Yentna River. Appendix Q provides additional information on EFH in the project area including an assessment of potential effects on these resources (Owl Ridge 2015c).

3.13.2.3.4 MACROINVERTEBRATES

Macroinvertebrate samples were collected at survey sites where riffle habitat was present. Collected samples were sorted and preserved with isopropyl alcohol for future analysis.

Table 3.13-21: Summary of Pipeline Route Stream Crossings (2010–2011)

Crossing Type	Status	Drainage				Total
		Cook Inlet	Skwentna	Yentna	Kuskokwim	
Pipeline Crossings	Anadromous (ADF&G)	1	12		15	28
	Anadromous (OT)	3	11		18	32
	Fish Captured	41	8	1	36	86
	No Fish Caught	22	24	2	58	106
	Not Sampled	59	39	1	71	170
	Total	126	94	4	198	422
Access Road Crossings	Anadromous (ADF&G)	2	3			9
	Anadromous (OT)				1	1
	Fish Captured	1	1		1	3
	No Fish Caught		2		1	3
	Total	3	6		7	16
Shoofly Road Crossings	Anadromous (ADF&G)		1			1
	Anadromous (OT)		1			1
	Fish Captured	1			1	2
	No Fish Caught		1		3	4
	Not Sampled		3	2	1	6
	Total	1	6	2	5	14
All Crossings Combined	Anadromous (ADF&G)	3	16	0	19	38
	Anadromous (OT)	3	12	0	19	34
	Fish Captured	43	9	1	38	91
	Total Fish Bearing	49	37	1	76	163
	No Fish Caught	22	27	2	62	113
	Not Sampled	60	41	3	72	176
	Total Non-Fish Bearing	82	68	5	134	289
Total		131	105	6	210	452

Notes:

The designation of non-fish bearing is based on sampling effort and may not be definitive as fish may use these waters at different times of year, or under different hydrologic conditions. Statuses listed as “not sampled” are already documented by ADF&G, or the stream is intermittent, meaning there is no chance of fish in those streams.

Source: OtterTail 2012b.

Table 3.13-22: Summary of Fish Species Composition per Drainage for the Pipeline Route (2010 to 2011)

Drainage	Mainstem	Tributary	Salmon						Non-Salmon																Total Species			
			Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink Salmon	Arctic grayling	Dolly Varden	Rainbow trout	Round whitefish	Humpback whitefish	Broad whitefish	Whitefish Sp.	Sheefish	Least cisco	Alaska blackfish	Alaskan brook lamprey	Lamprey Sp.	Burbot	Longnose sucker	Ninespine stickleback	Threespine stickleback	Northern pike		Coastrange sculpin	Slimy sculpin	
Cook Inlet	Beluga River	Mainstem	X1	X1		X1	X1					X1											X1		X1		7	
	Theodore River	Mainstem	X1	X1	X1		X1																X1				5	
		Tributaries	X																			X					2	
	Lewis R.	Tributaries	X						X	X																X	4	
	Alexander Cr.	Lower Sucker Cr.							X																	X	2	
		Bear Cr.		X1					X																	X	3	
		Clear Cr.							X										X			X				X	4	
		Deep Cr.							X														X			X	3	
Cook Inlet Total			X	X		X	X		X	X		X						X			X	X		X	X	12		
Skwentna	Skwentna R.	Mainstem	X1	X1	X1	X1	X1		X1	X1																X1	8	
	Eightmile Cr.	Mainstem3	X						X	X																	3	
		Tributaries	X						X	X																	3	
	Shell Cr.	Mainstem	X1		X	X1	X1																				4	
		Tributaries	X							X							X									X	4	
	Happy R.	Mainstem		X2		X2			X1																		X1	4
		Canyon Cr.		X1																							1	
		Squaw Cr.		X2		X2																				X1	3	
		Indian Cr.		X2					X																		2	
		Pass Cr.		X					X																	X	3	
		Sheep Cr.		X					X																		2	
		Tributaries	X2	X2	X	X		X	X	X										X		X	X			X	11	
Tributaries								X	X	X									X		X	X			X	11		
Skwentna Total			X	X	X	X	X	X	X								X		X		X	X			X	13		
Yentna	Yentna R.	Johnson Cr.	X						X											X		X			X	5		
Yentna Total			X						X											X		X			X	5		
Kuskokwim	S.F. Kuskokwim R.	Mainstem	X1	X1	X1				X1		X1			X1	X1											X1	8	
		Sidearm	X1						X1		X1															X1	4	
		Tatina R.	X						X2		X			X												X	5	
		Post R.	X	X					X1	X2		X														X2	6	
		High Lakes																									0	

Table 3.13-22: Summary of Fish Species Composition per Drainage for the Pipeline Route (2010 to 2011)

Drainage	Mainstem	Tributary	Salmon						Non-Salmon																	Total Species
			Coho salmon	Chinook salmon	Chum salmon	Sockeye salmon	Pink Salmon	Arctic grayling	Dolly Varden	Rainbow trout	Round whitefish	Humpback whitefish	Broad whitefish	Whitefish Sp.	Sheefish	Least cisco	Alaska blackfish	Alaskan brook lamprey	Lamprey Sp.	Burbot	Longnose sucker	Ninespine stickleback	Threespine stickleback	Northern pike	Coastrange sculpin	
		Tin Cr.							X																	
Kuskokwim (cont'd)	S.F. Kuskokwim R. (cont'd)	Sheep Cr.							X																	1
		Tributaries		X					X																X	3
	Windy F. Kuskokwim R.	Mainstem	X						X											X					X	4
		Khuchaynik Cr.																								0
		Tributaries							X																	1
	M.F. Kuskokwim R.	Mainstem	X						X2																X2	3
		Tributaries							X2															X2	2	
	Big R.	Mainstem	X1	X1	X1				X1					X1											X1	6
		Sidearm	X1	X1	X1				X1					X1											X1	6
		Tributaries							X																	1
	Tatlawiksuk R.	Mainstem	X2	X1	X1																					3
		Sidearm	X2	X1	X1																					3
		Tributaries	X2	X2				X2	X2								X			X					X2	7
	Kuskokwim R.	Mainstem	X1	X1	X1	X1		X1			X1	X1	X1	X1	X1	X1	X1	X1	X1	X1	X1			X1	X1	18
	Nunsatuk R.	Tributaries							X																X	2
	Moose Cr.	Mainstem	X						X																X	3
		Tributaries	X						X																	2
	George R.	Mainstem	X2	X1	X1			X1	X1					X1											X1	7
		E. F. George R.	X2	X1	X1			X1	X2		X1			X1					X1	X1		X1			X2	11
		N. F. George R.	X1	X1	X2				X1					X1											X1	6
		Tributaries		X1																						1
	Tributaries		X					X	X2								X						X		X2	6
	Kuskokwim Total			X	X	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X		X		X
Grand Total			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	24

Notes:
Refer to OtterTail 2012b for complete fish sampling data collected by OtterTail Environmental, Inc. An "X" does not indicate that the species occurs in all streams sampled, but rather was found in at least one stream within the drainage.
1 ADF&G data from Anadromous Waters Catalog and Alaska Freshwater Fish Inventory databases.
2 Found by OtterTail Environmental, Inc. and ADF&G data from Anadromous Waters Catalog or Alaska Freshwater Fish Inventory databases.
3 Mainstem Eightmile Creek was not sampled. Fish species assemblage collected from tributary sEIT2 that feeds the Eightmile Creek mainstem.
Source: ADF&G 2010; OtterTail 2012a.

Table 3.13-23: Summary of Fish Species Composition along the Pipeline Route (2010 and 2011)

Species Code	Drainage Area				Total # Crossings ¹	Species Codes		
	Cook Inlet	Skwentna	Yetna	Kuskokwim		Code	Common Name	Scientific Name
Ø	22	27	2	62	113	Ø	No fish caught	
DV	34	5		29	68	LS	longnose sucker	Catostomus catostomus
DV,SS	7	1		6	14	SS	slimy sculpin	Cottus cognatus
SS	1	1		1	3	AB	Alaska blackfish	Dallia pectoralis
CO,SS		3		3	6	NP	northern pike	Esox lucius
CO,DV		1		3	4	TS	threespine stickleback	Gasterosteus aculeatus
CO,RT		2			2	LA	Alaskan brook lamprey	Lampetra alaskensis
CO		1			1	BU	burbot	Lota lota
CO,DV,NS	2				2	P	pink salmon	Oncorhynchus gorbuscha
CO,K,DV,RW,SS				1	1	CH	chum salmon	Oncorhynchus keta
CO,DV,RW,W,SS				1	1	CO	coho salmon	Oncorhynchus kisutch
CO,CH,RT,NS,SS		1			1	RT	Rainbow trout	Oncorhynchus mykiss
CO,K,DV,BU,SS				1	1	S	sockeye salmon	Oncorhynchus nerka
CO,AG,AB,NP,SS				1	1	K	Chinook salmon	Oncorhynchus tshawytscha
CO,AG,AB,SS				1	1	RW	round whitefish	Prosopium cylindraceum
CO,DV,AB,SS				1	1	NS	ninespine stickleback	Pungitius pungitius
CO,RT,LA,SS		1			1	DV	Dolly Varden	Salvelinus malma
K,S,DV,SS		1			1	AG	Arctic grayling	Thymallus arcticus
CO,AG,SS				1	1	Notes: Table represents data collected in 2010 and 2011 along the proposed Donlin Gold natural gas pipeline. OtterTail 2012b. 1 A crossing is defined as the point where the proposed pipeline route crosses a stream. This table represents data collected within 1,000 feet upstream or downstream of a crossing (1,000 feet (304.8		
CO,NS	1				1			
CO,DV,SS				3	3			
CO,RT,SS		2			2			

Table 3.13-23: Summary of Fish Species Composition along the Pipeline Route (2010 and 2011)

Species Code	Drainage Area				Total # Crossings ¹	Species Codes		
	Cook Inlet	Skwentna	Yetna	Kuskokwim		Code	Common Name	Scientific Name
DV,AB				1	1	m) Buffer). Crossings previously documented as anadromous by ADF&G in the Anadromous Waters Catalog were not sampled and are not represented in this table.		
DV,RW				1	1			
AG,BU		1			1			
AG,BU,SS				1	1			
AB				1	1			
TS,SS	1				1			
TS			1		1			
RT		1			1			
Total # Crossings ¹	68	48	3	119	238			

Source: OtterTail 2012a.

3.13.2.3.5 CLIMATE CHANGE

Climate change is affecting resources in the EIS Analysis area and trends associated with climate change are projected to continue into the future. Section 3.26.3, Climate Change, discusses climate change trends and impacts to key resources in the physical and biological environments including atmosphere, water resources, permafrost, and vegetation. Current and future effects on fish and aquatic resources are tied to changes in water resources (discussed in Section 3.26.4).

3.13.3 ENVIRONMENTAL CONSEQUENCES

This section analyzes potential effects of the proposed project and alternatives on fish and aquatic resources from construction, operations, and closure activities associated with the proposed mine, transportation facilities, and pipeline. Supplementing this analysis is an assessment of project-related impacts associated with Alternative 2 on EFH (Appendix Q). The area of potential effect evaluated includes watersheds and downgradient aquatic habitats in the vicinity of these project components from headwater streams to marine waters. The intensity, duration, geographical extent, and context of potential impacts are considered in this analysis for each alternative and for all phases of the development life cycle from construction to closure, reclamation, and long-term monitoring.

Aquatic resources described in Section 3.13.2, Affected Environment, have been evaluated on the basis of certain pathways and mechanisms of potential impacts for various project components. For example, the key pathway of potential impacts to fish, other aquatic species, and their associated habitats affected by mining involves water. Mechanisms of potential mining impacts on aquatic resources include changes to water quality or quantity, in-stream or riparian habitat, and fish health, behavior, and migration access. These and other potential impacts have been evaluated for various project components and related activities over the project's life cycle (construction, operations, and closure) by considering direct and indirect effects to fish and aquatic resources as a result of:

- mine pits, fresh and contact water dams and water storage reservoirs;
- overburden stockpiles and waste rock facilities;
- tailings storage dam and impoundment;
- temporary and permanent access roads and runways;
- bulkheads/fills, and other overwater structures related to port terminals and barging;
- bridges, culverts, and pipeline/roadway stream crossings;
- equipment/materials storage/laydown areas;
- rock and aggregate materials sites;
- dewatering wells and related drainage/conveyance/detention/treatment systems;
- spill containment and waste treatment facilities;
- marine, truck, or air transport, storage, and handling of fuel and cargo;
- natural gas pipeline infrastructure; and

- collection, conveyance, treatment, and storage of waste and ore processing effluent.

Evaluating the pathways and mechanisms and related issues within the context of these project features and activities provides a basis for identifying the level of impact and avoidance/minimization and mitigation approaches that have been considered and, where appropriate, incorporated into the project alternatives.

Table 3.13-24 provides a summary of criteria used to assess the relative level of impacts to fish and aquatic resources for several mechanisms of effect (broadly associated with behavioral disturbance, habitat alterations, or injury/mortality/sustainability). These effects have been systematically assessed based on intensity, duration, geographic extent, and context as described below.

Table 3.13-24: Impact Criteria Used for Evaluating Fish and Aquatic Resources

Type of Effect	Impact Component	Effects Summary		
Behavioral Disturbance	Magnitude or Intensity	Low: Changes in behavior of fish or other aquatic biota due to project activity may not be noticeable; fish populations remain in the vicinity.	Medium: Noticeable changes in behavior of fish or other aquatic biota due to project activity that may affect reproduction, feeding, or survival of individuals.	High: Acute or obvious/abrupt change in fish or other aquatic biota behavior due to project activity; life functions are disrupted; populations are indirectly reduced in the EIS project area.
	Duration	Temporary: Behavior patterns of fish and other aquatic biota are infrequently altered, but not longer than the span of project construction and would be expected to return to pre-activity levels after actions causing impacts were to cease.	Long-term: Behavior patterns of fish or other aquatic biota are altered by ongoing activity and would return to pre-activity levels after actions causing impacts cease.	Permanent: Change in behavior patterns of fish or other aquatic biota would continue even if actions that caused the impacts were to cease; behavior would not be expected to return to previous patterns.
	Geographic Extent	Local: Impacts to fish or other aquatic biota would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Regional: Impacts would affect fish or other aquatic biota beyond a local reach of stream or watershed, potentially extending throughout the EIS project area including offshore marine waters.	Extended: Impacts would affect fish or other aquatic biota beyond the region or EIS project area.
	Context	Common: Impacts would affect individual fish or other aquatic biota that are common in the EIS project area and are not under special regulatory protection; populations would not be depleted in the locality.	Important: Impacts would affect individuals or populations of fish or other aquatic biota nearing depletion within the locality or region or that are subject to special regulatory protection.	Unique: Impacts would affect populations of fish or other aquatic biota subject to special regulatory protection; the affected populations fill a unique ecosystem role within the locality or region.
Habitat Alterations	Magnitude or Intensity	Low: Changes in the character or quantity of aquatic habitat may not be measurable or noticeable.	Medium: Changes in the character and quantity of aquatic habitat would be noticeable.	High: Changes to the character and quantity of aquatic habitat would be acute or obvious.

Table 3.13-24: Impact Criteria Used for Evaluating Fish and Aquatic Resources

Type of Effect	Impact Component	Effects Summary		
Habitat Alterations (continued)	Duration	Temporary: The character or quantity of aquatic habitat would be reduced infrequently but not longer than the span of 1 year and would be expected to return soon to pre-activity levels.	Long-term: The character or quantity of aquatic habitat would be reduced for the life of the project and up to 100 years.	Permanent: The character or quantity of aquatic habitat would not be anticipated to return to its pre-disturbance character or levels.
	Geographic Extent	Local: Impacts to aquatic habitat would be limited geographically to waters in the vicinity of the project footprint and the associated watershed(s).	Regional: Impacts to aquatic habitat would extend beyond a local reach of stream or watershed and potentially throughout the EIS project area including offshore marine waters.	Extended: Impacts to aquatic habitat would extend beyond the region or EIS project area.
	Context	Common: Impacts would affect aquatic habitat that is common in the EIS project area and is not subject to special regulatory protection; such habitat would not be depleted in the locality.	Important: Impacts would affect aquatic habitat that is becoming depleted within the locality or region or that is subject to special regulatory protection.	Unique: Impacts would affect aquatic habitat subject to special regulatory protection; the affected habitat fills a unique ecosystem role within the locality or region.
Injury and Mortality	Magnitude or Intensity	Low: No noticeable incidents of injury or mortality to individual fish or other aquatic biota; population level effects are not detectable.	Medium: Incidents of injury or mortality to individual fish or other aquatic biota are detectable; populations remain within normal variation.	High: Incidents of mortality or injury to individual fish or other aquatic biota create population-level effects.
	Duration	Temporary: Events with potential for causing mortality or injury to fish or other aquatic biota would occur for a brief, discrete period lasting less than one year, or up to the duration of construction.	Long-term: Events with potential for causing mortality or injury to fish or other aquatic biota would continue for up to the life of the project.	Permanent: Potential for mortality or injury to fish or other aquatic biota would persist after actions that caused the disturbance have ceased.
	Geographic Extent	Local: Impacts to fish or other aquatic biota would be limited geographically to the vicinity of the project footprint and the affected watershed.	Regional: Impacts would affect fish or other aquatic biota beyond a local reach of stream or watershed, potentially extending throughout the EIS project area including offshore marine waters.	Extended: Impacts would affect fish or other aquatic biota beyond the region or EIS project area.
	Context	Common: Impacts would affect individual fish or other aquatic biota that are common in the EIS project area and are not under special regulatory protection; individuals would not be depleted in the locality.	Important: Impacts would affect individuals or populations of fish or other aquatic biota nearing depletion within the locality or region or that are subject to special regulatory protection	Unique: Impacts would affect populations of fish or other aquatic biota subject to special regulatory protection; the affected populations fill a unique ecosystem role within the locality or region.

Conclusions summarizing anticipated impact levels for project components or alternatives are based on quantitative and qualitative thresholds and criteria described in Table 3.13-25.

Table 3.13-25: Impact Criteria

Impact Level	Description of Effect
No effect	The alternative would not affect the resource.
Negligible	Impacts are generally extremely low in intensity (often they cannot be measured or observed), are temporary, localized, and generally do not affect unique resources.
Minor	Impacts tend to be low intensity, of temporary duration, and local in extent, although common resources may experience more intense, longer-term impacts.
Moderate	Impacts are generally of medium intensity, short or long term duration, and local or regional extent, although common and important resources may be affected by higher intensity, longer term, or broader extent impacts. Unique resources may be affected by medium or low intensity impacts, shorter duration or intermittent episodes of impact over a long period, at a local or regional scale.
Major	Impacts are generally medium or high intensity, long-term or permanent in duration, a regional or extended scope, and affect important or unique resources that may be subject to regulatory protection.

3.13.3.1 ALTERNATIVE 1 – NO ACTION ALTERNATIVE

Under the No Action Alternative, the proposed mine site development, transportation infrastructure facilities, and natural gas pipeline would not be developed. This could result from the required permits not being approved by federal and state regulators, or because the applicant chose not to pursue the project. Consequently, project-related impacts on fish and aquatic resources, whether adverse or beneficial, would not occur. Existing land management trends or potential future developments (if any) may occur, but their associated impacts would not be related to the proposed project.

3.13.3.2 ALTERNATIVE 2 – DONLIN GOLD'S PROPOSED ACTION

All action alternatives would involve construction and operation of facilities and infrastructure required to mine, process, and produce gold from the Donlin Gold Mine to off-site markets. The following section describes potential impacts on fish and aquatic resources that would result from construction; operations and maintenance; and closure, reclamation, and monitoring of the mine site and the related facilities and infrastructure described in Chapter 2, Alternatives.

3.13.3.2.1 MINE SITE

As described in Chapter 2, Alternatives, mine site area development includes construction housing for the workforce; a power plant, utilities, services, and related infrastructure (e.g., fuel conveyance and storage facilities; roads and pads; and the transport, installation, and commissioning of facility modules); development of the proposed open pit mine, mill and ore processing, raw materials storage facilities, TSF, WRF and overburden stockpiles; and mine maintenance and safety controls. Most of these features would be constructed within the

Crooked Creek watershed which drains an area of about 333 mi² or less than 1 percent of the 50,000 mi² Kuskokwim River watershed.

The proposed features and facilities presenting potential risks to aquatic biota during construction, operations and maintenance, closure, and reclamation primarily involve those that ultimately could directly or indirectly alter or degrade surface or groundwater and aquatic habitats. This includes construction of mine site infrastructure, access roads, and related facilities; mining and earth moving activities; pumping/dewatering and other management practices involving groundwater, surface water, and stormwater; wastewater or contact water conveyance, treatment, and disposal; storage and handling of fuel, process chemicals/byproducts, and hazardous waste; and other site management practices near and upslope, or otherwise hydraulically connected to surface waters that might be a source of contamination. Such activities could result in several mechanisms or key factors that directly or indirectly affect aquatic resources including:

- In-stream habitat removal and disturbance or loss of fish and benthic biota;
- Water quality and water management practices;
- Wetland and riparian buffer removal;
- Streamflow changes;
- Stream temperature changes; and
- Erosion, sedimentation, and metals emissions.

Permit compliance requirements for the mine site, including standard and special terms and conditions, BMPs, and environmental monitoring, would be established by the Corps, FWS, NMFS, ADF&G, ADEC, ADNR, and other regulators with permitting authority. These requirements would be implemented as part of the construction management and facility operations plans to avoid, minimize, and control risks from proposed project activities on fish-bearing streams, EFH, and other surface waters in the Crooked Creek and Kuskokwim River drainages.

In-stream Habitat Removal and Fish Loss

Table 3.13-26 presents the anticipated stream channel distances within the mine site area where direct impacts to aquatic habitat would occur and corresponding estimates of anticipated fish losses. At the mine site area, there would be a total direct loss of 8 miles of perennial stream habitat consisting of 5.6 miles of aquatic habitat in American and Anaconda creeks. Of this, 0.66 mile is classified as anadromous waters and regulated as EFH. In addition, 2.36 miles of perennial stream habitat would be lost from direct impacts to Lewis and Snow gulches (non-anadromous waters). Virtually all of this loss would involve Lewis Gulch which studies have shown to be unoccupied by fish.

American Creek. Construction and operation of the open pit, WRF, and contact water dams would require removal of the stream channel in the American Creek watershed. This would cause an acute or obvious and permanent loss of 4.1 miles of perennial aquatic habitat and associated fish and macroinvertebrate populations in the mainstem of this tributary, about 0.5 mile of which is documented as an Anadromous Water for coho salmon rearing by ADF&G (Johnson and Daigneault 2013). In addition, there would be a permanent loss of other (non-fish)

aquatic life associated with about 6 miles of relatively small, perennial tributaries to the mainstem channel (OtterTail 2012b). During the mine closure phase, drainage from the reclaimed WRF would be directed through a newly constructed channel for American Creek that would terminate in a pit lake downstream of the WRF. As a result, the American Creek drainage would experience an obvious/abrupt and permanent loss of aquatic habitat and fish.

As shown in Table 3.13-26, habitats that would be lost in this drainage have fish populations that have been determined to consist of slimy sculpin (73 percent), Dolly Varden (14 percent), coho salmon (11 percent), and less than 1 percent each for Arctic grayling and burbot. Based on the species and density of fish populations captured in this drainage, habitat elimination could result in a predicted loss of approximately 4,300 fish (Table 3.13-26), however, an unknown proportion of these could be displaced to other stream segments in the drainage which may or may not be at carrying capacity. The greatest number and proportion of potential fish loss (about 2,800 or 65 percent) would involve Dolly Varden, and about 200 age 0 and age 1 juvenile coho salmon. Additional losses are anticipated for slimy sculpin, Arctic grayling, and burbot.

The anticipated level of impact to American Creek would be moderate based on the high intensity and permanent loss of local fish and aquatic habitat, a half-mile of which is considered important since it is classified as EFH. In addition, a low intensity of indirect impacts to aquatic habitat is anticipated in localized areas of Crooked Creek immediately downstream of the American Creek confluence due to reduced recruitment of sediment and woody debris from the American Creek watershed, which represents about 2 percent of the Crooked Creek watershed.

Lewis Gulch. Construction and operation of the open pit would permanently eliminate 2.3 miles of perennial aquatic habitat in Lewis Gulch. A medium intensity of impacts on aquatic resources in this drainage is expected since an acute or obvious loss of aquatic habitat would occur that is common in the area. This drainage is not regulated as EFH and no fish were observed or captured here during 2009 electrofishing surveys (OtterTail 2012b). Lower portions of the stream have been disrupted and channelized by historic placer mining operations. In addition, habitat removal in Lewis Gulch would result in a low intensity of indirect impacts in Crooked Creek because of the reduced recruitment of sediment and woody debris from Lewis Gulch. This would result in localized permanent changes to the character and distribution of aquatic habitat immediately downstream from the Lewis Gulch confluence.

Anaconda Creek. Construction and operation of the TSF would cause an acute and permanent loss of approximately 70 percent of the stream channel within the Anaconda Creek watershed. Direct loss would involve about 1.5 miles of aquatic habitat and associated fish and macroinvertebrate communities as a result of the complete burial of the main channel by the TSF. Catalogued as an Anadromous Water for coho salmon rearing by ADF&G (Johnson and Daigneault 2013), fish population densities in Anaconda Creek were determined to be considerably lower than American Creek and other similarly sized Crooked Creek drainages (Table 3.13-26). Construction and operation of the TSF in the Anaconda Creek watershed would result in instream habitat impacts of a high intensity involving a permanent fish loss of a local population of about 90 Dolly Varden. Immediately downstream from the Anaconda Creek confluence in Crooked Creek, a low intensity of permanent indirect impacts to the morphological character and availability of certain instream habitat constituents are anticipated due to the reduced recruitment of stream substrates and large woody debris from this drainage. In addition, a permanent loss of other (non-fish) aquatic life is anticipated associated with 4.67 miles of relatively small, perennial tributaries to Anaconda Creek (OtterTail 2012b). Although

the affected stream channel was found to have low fish densities, the lower reaches of this drainage are important in context since they are regulated as EFH. As a result, anticipated impacts in this drainage, which represents about 2 percent of the Crooked Creek watershed, would be considered moderate.

Snow Gulch. Construction and operation of a dam and freshwater reservoir in the middle reach of the Snow Gulch watershed is proposed as a source of freshwater for the ore processing plant. The dam would displace 262 feet (0.05 mile) of stream channel, while the reservoir (at full capacity) would convert 0.89 mile of stream habitat upstream of the constructed dam into open-water lake habitat. In-stream construction at the dam site would cause a direct and permanent loss of habitat within the affected stream channel resulting in the potential loss or displacement of a small population of Dolly Varden, estimated at about three fish. Dam construction, which would create a fish migration barrier, would be noticeable and of a medium level of intensity as fish seek aquatic habitat undisturbed by construction (Table 3.13-26). While the newly created reservoir likely would not result in direct losses of fish upstream of the proposed dam, indirect effects to fish in the downstream segment (estimated at about 60 Dolly Varden) could occur as a result of reduced flows depending on how water releases below the proposed dam are managed. In addition, fish passage has not been incorporated into the dam structure so Dolly Varden, or other species of fish, would not be able to migrate from the lower reaches of Snow Gulch, or Crooked Creek, past the dam into the upper watershed. While two coho salmon adults were observed in the lower portions of Snow Gulch in 2008, ongoing placer mine operations since then have likely precluded upstream migration of adult coho salmon and other fish from Crooked Creek into Snow Gulch (OtterTail 2012b).

An unknown number of Dolly Varden that would be isolated in the upper watershed by the proposed dam may periodically pass downstream over the dam's spillway. Large woody debris, however, would not be able to pass from the upper watershed over the spillway into the lower reaches of this stream. This may result in an undetermined reduction of fish rearing and refuge habitat and woody substrate materials that support fish and aquatic invertebrates downstream of the dam (House and Boehne 1986; Marcus et al. 1990). Unless the reservoir above the proposed dam would become filled with sediment (which is not expected), its deeper water would offer substantial additional overwintering and foraging habitat for the population of Dolly Varden and other fishes that may become isolated upstream of the dam. Although there are uncertainties related to predicted instream habitat loss offset by increased overwintering and foraging habitat in the created reservoir, the net impact to fish populations in Snow Gulch, considered common to the Crooked Creek drainage, would be expected to be minor. Snow Gulch represents only about 1 percent of the Crooked Creek watershed.

Table 3.13-26: Direct Aquatic Habitat Loss and Corresponding Predicted Fish Loss for Streams within the Facilities Study Area

Stream	Facility	Sampling	Distance Removed ¹		Fish		Fish Population Estimates ²				Fish Removed ³	
		Site	mi	km	Species	% Composition	#/mi	SE	#/km	SE	#	SE
American Creek	Open Pit	AM1	1.58	2.54	Dolly Varden	14.4	161	33	100	20	254	52
					Slimy sculpin	73.3	818	316	508	196	1,289	498
					Arctic grayling	0.7	8	5	5	3	13	9
					Burbot	0.5	5	3	3	2	8	5
					Coho salmon	11.1	123	61	77	38	194	96
	Open Pit Subtotal		1.58	2.54		100.0	1,116	419	693	260	1,758	660
	WRF Subtotal	AM2	2.51	4.05	Dolly Varden	100.0	1,003	379	623	236	2,522	953
	Total		4.09	6.59			2,119	798	1,316	496	4,280	1,613
Anaconda Creek	TSF	AN2	1.53	2.46	Dolly Varden	100.0	61	17	38	11	92	26
Snow Gulch	Freshwater Reservoir	SN2	0.05	0.08	Dolly Varden	100.0	69	29	43	18	3	1
Lewis Gulch	Open Pit	LE1	2.31	3.72	No Fish Collected	0.0	0	na	0	na	0	na
Totals			7.98	10.38			2,249	845	1,397	525	4,376	1,641

Notes:

1 Distances were calculated using only the mainstem portions of affected streams assuming side drainages have limited to no fish populations. Distances removed reflect infrastructure conditions based on ARCADIS geographic information system (GIS) datasource: INFRASTRUCTURE_2011_OP_POLY dated 5/17/2011.

2 OtterTail's electrofishing population estimates are based on single pass electrofishing results.

3 Fish removed estimates = (# fish/mile)*(miles removed). Because fish populations are distributed unevenly, these numbers should be considered an estimate. Sites AM1, AM2, AN2, SN2, and LE1 shown on Figure 3.13-1.

SE -Standard error for fish population estimates = standard deviation/ \sqrt{n} years sampled).

Source: OtterTail 2012b.

Water Quality and Water Management Practices

Non-contact freshwater, including surface water flows and stormwater runoff, would be intercepted at the mine site to control erosion, avoid contact with stockpiles and other mining infrastructure, and minimize potential water quality impacts to aquatic biota (Figures 2.3-6 and 2.3-7, Chapter 2, Alternatives). Collected non-contact freshwater would be conveyed to stormwater/sedimentation and storage facilities before being returned directly to other tributaries downstream or Crooked Creek. While it is possible the outflows from such storage facilities could have reduced levels of suspended sediments, this likely would be offset by silt-laden runoff that naturally enters these drainages downstream where stream banks and channels are incised, erodible, and silt-laden, irrespective of mine development. A temporary fresh water diversion dam (FWDD) would be constructed in American Creek during the first year of operations to minimize flows to the lower contact water pond in the early stages of the WRF use. Flows exceeding the capacity of the dam would be discharged out of the American Creek drainage to Omega Gulch and Crooked Creek. Two additional temporary FWDDs would be constructed in the tributaries upstream of the TSF on Anaconda Creek to minimize runoff into the facility. Water from upper Anaconda Creek would be diverted around the TSF and released downstream. A dam also would be constructed on the middle section of Snow Gulch to provide a supply of freshwater for consumption during operations.

Contact water is defined as surface water or groundwater that has contacted mining infrastructure, and includes 'mine drainage' defined in the Code of Federal Regulations (40 CFR 440.132(h)) as *any water drained, pumped, or siphoned from a mine*. As described in Chapter 2, contact water will involve a variety of sources including surface water, stormwater runoff, snowmelt, and groundwater seepage. Contact water also would include drainage from the open pits, WRF, and stockpiles conveyed to the lower and upper contact water ponds in American Creek where it would be stored and reclaimed for use in ore processing. During the operations and maintenance phase of Alternative 2, groundwater from the pit-perimeter and in-pit dewatering wells would be routed to the water treatment plant prior to discharge in Crooked Creek at the selected discharge point in Crooked Creek below Omega Gulch (BGC 2015c). All water routed to the water treatment plant would be treated to meet applicable water quality requirements and standards of the APDES permit before discharge. Contact water that is not treated would be reused in the process circuit throughout the operations phase. Compliance monitoring would be conducted to assure that water quality standards during mine operations, closure, and reclamation are maintained and so potential water quality impacts on fish and aquatic life in the Crooked Creek drainage would be avoided or minimized. Specific monitoring standards and testing protocols would be stipulated in discharge permits.

Perimeter wells around the ACMA and Lewis open pits would remove groundwater during pre-construction, construction, and operations and maintenance phases of the mine to ensure the stability of pit walls. Additional in-pit dewatering wells would be installed at lower elevations as the pit deepens. Although not considered contact water, water from dewatering wells (about 1,400 gpm) would be conveyed to the water treatment plant and treated in compliance with APDES permit requirements and ADEC water quality standards to ensure protection of aquatic life.

During mine operations, about two-thirds of the groundwater intercepted from the in-pit wells would be treated and discharged to Crooked Creek below Omega Gulch (CCBO). The remaining third (about 460 gpm or less than 1 cfs) would be conveyed to the process plant

where it would be consumed as a source of freshwater. Diverting less than 1 cfs of the groundwater intercepted by dewatering wells to the process plant would have a de minimis effect on fish habitat and associated populations in Omega Gulch since fish are not known to utilize this drainage. Alterations of streamflow and effects on fish and aquatic habitat in Crooked Creek and its tributaries are described subsequently in this and Section 3.5, Surface Water Hydrology.

During mining, water withdrawals from the in-pit and perimeter dewatering wells would result in a cone of depression of the groundwater level that would extend beyond and below the footprint of the open pit and dewatering well system. By the time mining ends, the western perimeter of the open pit would extend to within 980 feet of Crooked Creek, with the pit depth about 1,310 feet below the elevation of the creekbed. As shown in Figure 3.13-6, the anticipated zone of groundwater drawdown would extend west to Crooked Creek from Queen Gulch to Omega Gulch. The decrease in groundwater discharges that would normally support baseflow stream conditions, the decreased rate of aquifer recharge because of stream leakage, and the diversion of flows at the mine site would have a combined effect that would reduce surface flows in mine site area tributaries and in the middle reaches of Crooked Creek (BGC 2014c, 2015c).

During closure, pit de-watering activities would cease operation and, over time, surrounding groundwater levels would eventually recover to pre-dewatering conditions. About 60 years after mining ends, water would fill the pit until it reaches an elevation of 331 feet above MSL or about 10-30 feet below the level of Crooked Creek. The water elevation in the pit would be managed at this level by pumping water to a treatment facility to ensure discharges to Crooked Creek are in compliance with applicable water quality standards established to protect aquatic life and as specified in the APDES discharge permit.

During mine operations and closure phases, water from the treatment plant would be discharged to Crooked Creek below Omega Gulch between the confluence of American Creek and Anaconda Creek. Compliance monitoring at the point of discharge would assure that water quality standards are maintained so potential impacts to fish and aquatic life would be avoided or minimized. Specific monitoring requirements will be included in the APDES discharge permit in accordance with ADEC water quality standards.

As a result, potential water quality impacts on fish and aquatic habitat in Crooked Creek would occur at a low level of intensity that would be permanent, extending from construction through post-closure monitoring. Potential impacts of a medium level of intensity could occur, primarily during construction, for tributary drainages directly affected by earth moving and grading activities. The geographic extent of potential water quality impacts would be local and limited to the Crooked Creek drainage primarily near the mine site. Such impacts would have an important context since Crooked Creek and the lower reaches of American and Anaconda creeks have special regulatory protection as EFH. Therefore, anticipated impacts on water quality in the affected tributaries and in Crooked Creek would be minor.

Wetland and Riparian Buffer Removal

Wetlands provide important natural functions that benefit aquatic biota. These include water storage, water quality maintenance, and (where there are direct connections to perennial streams) fish rearing habitat. Water quality functions occur through a variety of mechanisms including physical processes whereby debris and suspended solids may be removed from

surface waters by filtering and sedimentation. In addition, nutrients and dissolved solids may be removed or degraded by biological processes, or incorporated into plant biomass. Similarly, microbial activities that occur in oxygen-depleted wetland sediments may chemically reduce certain forms of iron and sulfate so they become removed from water as insoluble precipitates. Other water quality functions can be provided by reducing the solubility, mobility, and bio-availability of certain metals that become captured within sediments. For example, arsenic (in association with iron) has been shown to accumulate in wetlands in areas influenced by mining (SRK 2012b).

Under Alternative 2, clearing, excavations, grading, surface water diversions, and groundwater dewatering would directly or indirectly disturb or eliminate wetlands, riparian buffers, and upland vegetation in the American Creek, Omega Gulch, Anaconda Creek, Snow Gulch, and Crooked Creek drainages. Adverse impacts to local fish populations would occur where wetlands and riparian plant communities that provide off-channel fish habitat or other natural functions along perennial streams are permanently eliminated or where water sources needed to sustain wetland communities are removed. Loss of water storage and infiltration functions can affect baseflow conditions in downstream reaches of these drainages and in Crooked Creek. Wetland loss also can increase runoff and flooding that can adversely affect aquatic habitats. Elevated stream temperatures also could occur when trees and other riparian plants are removed.

In lower elevations of drainages near the mine site, wetlands that are connected to underlying aquifers that supply groundwater from within about 16 feet of the surface (rather than from a perched groundwater source) would have a high likelihood of indirect impacts for those wetlands located within the simulated drawdown cone of depression from mine dewatering operations (BGC 2015b). Such impacts are predicted to affect a total of about 550 acres of wetlands. This includes 104 acres classified as riverine wetlands or river channel involving 1.3 miles of intermittent streams and 5.5 miles of perennial streams. Wetland functions in these wetlands related to the capture and transfer of nutrients, suspended solids, metals, or other soil constituents also would be adversely affected by direct and indirect effects to wetlands.

As mentioned previously, wetland impacts also can affect the capture and distribution of certain metals including arsenic, mercury, lead, and zinc that would otherwise be retained in wetland sediments. As wetlands are filled, metals-containing runoff from natural sources or mining operations would be conveyed to local surface waters instead of being filtered and retained. Potential effects of wetland losses on water quality in the MSA are expected to be offset by the capture and treatment of water that comes into contact with disturbed soils or mine drainage prior to discharge to Crooked Creek. Additional information on potential impacts of metals associated with wetlands and fish resources is described in the subsequent section on erosion and sedimentation. Anticipated effects on wetlands as a result of Alternative 2 would be of a medium to high intensity and local in extent involving sub-drainages in the Crooked Creek watershed. Effects associated with perennial streams that support salmon populations would have an important context since they would be regulated as EFH. Depending on the wetlands affected, the duration of impacts would range from short-term (5 years) during construction and restoration to long-term through the operations and maintenance phase when pit de-watering activities end. The overall impact of construction on wetlands through closure and reclamation would be considered moderate.

Further information on the nature and extent of wetland impacts as related to surface and groundwater hydrology and water quality in the Crooked Creek drainage is provided in Sections 3.11, Wetlands; 3.5, Surface Water Hydrology; 3.6, Groundwater Hydrology; and 3.7, Water Quality.

Streamflow Changes and Overall Aquatic Habitat

Fish and aquatic biota can be affected by alteration of flow regimes that, in turn, modify sediment transport and other mechanisms that define the geomorphological character of streams and other water bodies. Specific changes occur on the basis of stream type; geologic, geomorphic, and climatic factors that influence channel stability; and the magnitude and duration of altered flows.

Increases in flow can create excessive shear stress and other hydraulic forces that result in aquatic habitat alteration from channel enlargement or degradation and excessive bank erosion. Other impacts from increased flow may include increased energy consumption by fish of various life stages as they encounter higher water velocities; rearing and migration habitat that becomes more restricted to backwaters and the margins of stream channels; and elevated turbidity, increased suspended sediment loads, and decreased sediment deposition. Beneficial impacts may include increased pool depth; increased stream wetted area; increased duration of mainstem connectivity to off-channel habitats; increased recruitment and transport of spawning substrates; decreased probability of bottom freezing events in winter and associated increased overwinter survival rates for fish and macroinvertebrates; and in extreme cases, the elimination of fish migration barriers.

Decreases in flow can reduce shear stress and other hydraulic forces within stream channels resulting in a loss of sediment transport capacity and causing channel aggradation. Changes in these mechanisms can alter the availability and quantity/quality of aquatic habitat; channel morphology; connectivity to both off-channel and upstream habitats; downstream macroinvertebrate drift and overwintering survival; and changes in water quality. Other potential impacts of decreased flow include decreased stream-wetted areas; decreased pool depth; and increased probability of bottom freezing in winter causing reduced overwinter survival rates for macroinvertebrates and fish. Stream bed freezing events can particularly affect incubating fish eggs and newly hatched fry occupying stream gravels. In extreme cases, winter freeze events during periods of low flow can, at times, form complete barriers to fish passage. Potential beneficial impacts of decreased flow may include reduced stream bank erosion and channel down-cutting; decreased sedimentation and turbidity; and increased availability of productive shallow-water habitat along stream margins.

During the operations and maintenance phase, surface runoff in many parts of the MSA resulting from rainfall, snowmelt, and groundwater seepage would be diverted and captured (stored). These waters would be subsequently entrained in the tailings, lost in the milling processes, consumed in the power plant operations, or lost to the atmosphere through evaporation, or treated based on an advanced water treatment (AWT) process prior to release to Crooked Creek near the confluence of Omega Gulch. In addition, flows from pit dewatering and perimeter wells would be diverted and transferred to storage reservoirs for use in mill processing operations or treated and released to Crooked Creek near the confluence of Omega Gulch.

Pit dewatering operations, diversion of stormwater and surface flows from American Creek and other drainages east of Crooked Creek, advanced water treatment, and other water management practices as previously described were considered in combination with groundwater and surface water modeling as part of an integrated modeling approach to predict flow reductions in the mainstem of Crooked Creek in response to proposed mining during operations and maintenance, and after mine closure. Based on the analysis, the greatest flow reductions in Crooked Creek were predicted to occur in reaches adjacent to the open pits, primarily from the confluence of American Creek to below Crevice Creek, during winter as described below (BGC 2014c, 2015c). Regardless of the final use or consumption of these waters, flows ultimately reaching Crooked Creek would be less than the historical seasonal variations during average and low-flow years (BGC 2013f, 2014c, 2015c).

Near the mine site, predicted maximum flow reductions in the mainstem of Crooked Creek would be greatest during typical low-flow periods of winter (December to March). A maximum flow reduction of 33 percent is predicted to occur in March for Year 20 based on a 10th percentile low-flow-year scenario. Based on the average flow year scenario, predicted winter maximum flow reductions in Year 20 would be greatest in January at 23 percent (BGC 2015c).

As shown in Table 3.13-27, predicted maximum reductions of winter low flows in Crooked Creek from the American Creek confluence to below Crevice Creek would reduce aquatic habitat surface area by a total of about 4 acres (from 75.98 to 71.78 acres) or 6 percent with about 1 acre of this consisting of riffle habitat and nearly 3 acres consisting of run habitat. Pool habitat within this overall reach would be reduced by about a quarter acre. The greatest reduction in aquatic habitat surface area within this reach is predicted to occur below Crevice Creek. In this reach, aquatic habitat surface area would be reduced by a total of 2.65 acres with nearly 2 acres of this consisting of run habitat.

Based on the proposed mining operations under Alternative 2, predicted maximum flow reductions in Crooked Creek would be greatest during winter, particularly in January (representing the typical lowest flows for a 50th percentile average flow year) and March (representing the typical lowest flows for a 10th percentile low flow year). More severe flow reductions also have been predicted, under a *High K* scenario, should geologic conditions ultimately reflect a high level of hydraulic conductivity between the Crooked Creek streambed and the underlying zone of groundwater depression caused from the operation of the pit dewatering wells.

To evaluate the sensitivity of the predictive model relative to flow reduction estimates and the degree of hydraulic conductivity, the model will be reviewed after the initial 3 years of dewatering and every 5 years thereafter. Table 3.5-26 (Surface Water Hydrology) presents predictions of the percent flow reductions in Crooked Creek, and in the mine site area tributaries, during Year 10 and Year 20 of mine operations for low flow, average flow, and low flow - *High K* conditions. A summary of the table is as follows:

During Year 10 of operations, the maximum winter flow reductions in stream reaches near the mine site (between the confluence of American Creek and below Crevice Creek) and in lower Crooked Creek would vary from:

- 16-20 percent in January based on an average flow year scenario; flows would be reduced by 18 percent at Crevice Creek, 9 percent below Getmuna Creek, and 7 percent below Bell Creek;

- 22-28 percent in March based on a low flow year scenario; flows would be reduced by 23 percent at Crevice Creek, 11 percent below Getmuna Creek, and 9 percent below Bell Creek;
- 45-60 percent in January based on an average flow year and *High K* scenario; flows would be reduced by 45 percent at Crevice Creek, 21 percent below Getmuna Creek, and 16 percent below Bell Creek; and
- 76-100 percent in March based on a low flow year and *High K* scenario; flows would be reduced by 76 percent at Crevice Creek; 36 percent below Getmuna Creek, and 28 percent below Bell Creek.

During Year 20 of operations, the maximum winter flow reductions in stream reaches near the mine site and in lower Crooked Creek would vary from:

- 18-23 percent in January based on an average flow year scenario; flows would be reduced by 20 percent at Crevice Creek, 10 percent below Getmuna Creek, and 7 percent below Bell Creek;
- 25-33 percent in March based on a low flow year scenario; flows would be reduced by 26 percent at Crevice Creek, 12 percent below Getmuna Creek, and 10 percent below Bell Creek;
- 49-67 percent in January based on an average flow year and *High K* scenario; flows would be reduced by 49 percent at Crevice Creek, 23 percent below Getmuna Creek, and 18 percent below Bell Creek; and
- 85-100 percent in March based on a low flow year and *High K* scenario; flows would be reduced by 85 percent at Crevice Creek, 40 percent below Getmuna Creek, and 31 percent below Bell Creek.

During Closure, after the pit lake is filled and at capacity, winter flow reductions in Crooked Creek would be considerably less in stream reaches between the confluence of American Creek and below Crevice Creek and in lower Crooked Creek as compared to Year 10 or 20 of operations (see Table 3.5-26 and Table 3.5-28 in Surface Water Hydrology). During mine closure, maximum flow reductions would vary from:

- 11-13 percent in January based on an average flow year scenario; flows would be reduced by 12 percent at Crevice Creek, 6 percent below Getmuna Creek, and 4 percent below Bell Creek; and
- 13-17 percent in March based on a low flow year scenario; flows would be reduced by 13 percent at Crevice Creek, 6 percent below Getmuna Creek, and 5 percent below Bell Creek.

During summer operations (May to October), flow reductions are predicted to be less due to the seasonally higher levels of surface flows from the upper Crooked-Donlin Creek watershed.

Based on flow reduction estimates developed for the Year 20 low-flow scenario as described above, the intensity of impacts to aquatic habitat would range from medium to low. In the middle reaches of Crooked Creek near the mine, winter low flows could be reduced by up to 33 percent. In lower Crooked Creek below Getmuna Creek, winter low flows could be reduced by 12 percent. Except for the *High K* scenario, flow reductions near the mine would be offset in

lower Crooked Creek by substantial tributary inflows from the undisturbed Getmuna and Bell creek drainages. Under a *High K* scenario, however, the intensity of impacts to aquatic habitat in reaches near the mine and in lower Crooked Creek would be high. Flow reductions up to 100 percent could occur near the mine site, while farther downstream reductions of 40 percent are predicted below Getmuna Creek where a high proportion of the salmon spawning and rearing in the Crooked Creek drainage occurs.

The geographic extent of such impacts on the Crooked Creek mainstem would be local extending primarily from the confluence of Queen Gulch to the confluence of Crevice Creek. The duration of surface flow reductions in the affected tributaries and middle reaches of Crooked Creek would be long-term extending to the closure phase. During closure with the pit lake at capacity, flow reductions in Crooked Creek from the MSA to the Kuskokwim River confluence would persist but at a low level of intensity. The context of flow impacts is important since the Crooked Creek drainage from its mouth to the Donlin Creek drainage is regulated as EFH as it supports key life stages of salmon and other fish that are important to the Kuskokwim River subsistence community. Overall, streamflow reductions would result in aquatic habitat impacts that would range from moderate to minor and could be major under a *High K* scenario. Section 3.5, Surface Water Hydrology; Section 3.6, Groundwater; and Section 3.7, Water Quality, provide additional information on predicted surface water and groundwater flow modifications related to the proposed project.

Invasive Species

Fish and aquatic biota and habitat can be affected by invasive species introduced to streams, lakes, ponds, wetlands, and other aquatic habitat in the mine site. Increased activity at the mine site may increase the potential for aquatic plant invasive species introduction. Currently 26 invasive plant species are known from the Project Area, including 12 at the mine site; none are aquatic invasive plant species. One invasive plant species, elodea (*Elodea canadensis*, *E. nuttallii*, and hybrids) is known with the state of Alaska and could survive in habitats within the Project Area. A 2014 USFWS survey of a lake near Bethel revealed no elodea. Elodea can be transported by vectors including freshwater vessels, floatplanes, birds such as waterfowl, gear, and equipment. See Table 3.13-29 for a complete list of all aquatic invasive risk species (freshwater plants, marine plants, are marine animals). Impacts to the mine site for aquatic freshwater plant species would be low as floatplane use is not anticipated. Risk of introduction through construction equipment, gear, and other vectors is possible but low. Introduction prevention and control is discussed in more detail in Section 3.10, Vegetation, including details of terrestrial invasive plant species and associated BMPs, invasive species transport vectors, and Donlin Gold's Invasive Species Management Plan (ISMP).

Streamflow Changes and Off-channel Aquatic Habitat

During the construction; operations and maintenance; and closure, reclamation, and monitoring phases, a reduction in Crooked Creek streamflow could cause geomorphic changes to the stream channel. This could include a slight narrowing of the bank full width of the channel and encroachment (expanded growth) of riparian vegetation. Reduced flows also could affect the frequency with which off-channel habitat maintains connection with the main channel. This is an important consideration because although off-channel habitats would likely re-connect to the main channel at some point during the year when the water stage increases, connections may no longer occur during very low flow periods in summer or winter resulting in temporary

isolation of off-channel habitats from the main channel. This could affect rearing or spawning life phases of fish due to fish stranding and potential mortalities. Furthermore, a reduction in off-channel (or in-channel) winter habitat may adversely affect the survival of overwintering fish or incubating eggs if flows are reduced to the point where the water column becomes too shallow and freezes completely. Fish species potentially affected by flow reductions along various reaches of Crooked Creek and its tributaries in the lower, middle, and upper watershed are described in Section 3.13.2.1.2.

As shown in Table 3.13-28, the number of off-channel units and corresponding areas connected to the main channel relative to estimates of total off-channel habitat surface area were calculated for baseflow conditions minus 16 percent, at baseflow, and at increasing levels of flow representing 25, 50, 75, and 100 percent of bankfull stage (OtterTail 2012e). A series of maps, covering a distance of about 33 miles, of various habitat types extending from the convergence of Flat Creek and Donlin Creek to the mouth of Crooked Creek was developed from field surveys conducted from August 14 to September 15, 2009 (OtterTail 2014a). The average discharge during the study was 202 cfs at the USGS gauge at Crooked Creek. At the confluence of Bell Creek and Crooked Creek, upstream of the USGS gage, the calculated low flow for this time period is 260-273 cfs while the average flow is 531-540 cfs (BGC 2014c).

From the convergence of Donlin Creek and Flat Creek to the confluence of Crooked Creek at the Kuskokwim River, nearly three quarters (73 percent) or about 15 acres of the off-channel habitat surface area is connected to the main channel at baseflow conditions. A 16 percent flow reduction from baseflow conditions, based on predicted flow depletion estimates in Year 20 of operations, would result in a 9 percent reduction in off-channel habitat connectivity (from 73 to 64 percent). This would result in a medium intensity of impact on connected off-channel habitat surface area (reduced by 4 acres, from 15.3 to 11.3 acres, or 26 percent) (OtterTail 2012e). Reductions in off-channel habitat connectivity also were evaluated for specific reaches along Crooked Creek as described below.

From the convergence of Donlin Creek and Flat Creek downstream to American Creek, Crooked Creek has a high percentage (89 percent) of off-channel habitat surface area connected to the main channel at baseflow conditions. This represents a high frequency of off-channel habitat connectivity to the main channel during an average flow year. A 16 percent flow reduction from baseflow conditions, based on predicted flow depletion estimates in Year 20 of operations, is predicted to result in less than a 5 percent reduction in off-channel habitat connectivity (from 89 to 84 percent). This would reflect a relatively low intensity of impact on connected off-channel habitat surface area (reduced by 0.13 acre, from 0.66 to 0.53 acre, or 20 percent) (OtterTail 2012e).

From American Creek downstream to Anaconda Creek, Crooked Creek also has a high percentage of off-channel habitat surface area connected to the main channel at baseflow conditions (97 percent). A 16 percent flow reduction from baseflow conditions is predicted to result in <1 percent change in off-channel habitat connectivity and a low intensity of impact on connected off-channel habitat surface area (reduced by 0.37 acre, from 2.20 to 1.83 acres, or by 17 percent) (OtterTail 2012e).

From Anaconda Creek to Crevice Creek, predicted baseflow reductions in Crooked Creek in Year 20 of operations would have the greatest effect on off-channel habitat connectivity during low flow conditions of summer and winter, especially during dry years. About 1.8 acres of off-channel habitat surface area within this reach is connected to Crooked Creek at baseflow

conditions. A 16 percent reduction from baseflow conditions is predicted to result in two backwater habitat units losing their connectivity with the main channel. This would result in a low intensity of impact on connected off-channel habitat surface area (reduced by 0.93 acre, from 1.75 to 0.82 acre, or by 53 percent) (OtterTail 2012e).

From Crevice Creek to Getmuna Creek, Crooked Creek has about 66 percent of its off-channel habitat surface area connected to the main channel at baseflow conditions. A 16 percent reduction from baseflow conditions in this reach is predicted to result in two backwater habitat units experiencing a reduced frequency of connectivity with the mainstem. This would result in a medium intensity of impact on connected off-channel habitat surface area (reduced by 2.47 acres, from 8.22 to 5.75 acres, or by 30 percent) (OtterTail 2012e). Tributary contributions along this section, particularly from post-closure diversion flows into and from Crevice Creek and from Bell Creek farther downstream, are expected to moderate the impacts of predicted baseflow reduction downstream of Crevice Creek.

From Getmuna Creek to the Kuskokwim River confluence, Crooked Creek has about 64 percent of its off-channel habitat surface area connected to the main channel at baseflow conditions. A 16 percent reduction from baseflow conditions in this reach is predicted to result in one backwater habitat unit experiencing a reduced frequency of connectivity with the mainstem. This would result in a low intensity of impact on connected off-channel habitat surface area (reduced by 0.11 acre, from 2.45 to 2.34 acres, or by 4 percent) (OtterTail 2012e).

Along the Crooked Creek corridor between Donlin Creek and the Kuskokwim River, flow reductions have been predicted for Year 10 and Year 20 of operations (BGC 2015c). During the typical driest month of the year (March) under a 10th percentile low-flow year scenario for Year 20 of operations, flows in Crooked Creek at the American Creek confluence are predicted to be reduced by a maximum of 33 percent. As a result of tributary inflows farther downstream near Bell Creek, flow reductions are predicted to be lessened to 10 percent. During mine closure, after the pit lake is filled to capacity, winter flow reductions in Crooked Creek would be considerably less in stream reaches between the confluence of American Creek and below Crevice Creek and in lower Crooked Creek as compared to Year 10 or 20 of operations. Near the mine site, flow reductions in Crooked Creek would range from a maximum of 11-13 percent during March of a typical low flow year with reductions of 6 percent below Getmuna Creek and 5 percent below Bell Creek.

Under such low-flow scenarios, the overall intensity of predicted flow reductions on connected *off-channel* habitat surface area could range from low (in lower Crooked Creek) to medium (near the mine site) during mine construction and operations phases. Between American Creek and Crevice Creek, impacts on connected *off-channel* habitat would primarily involve local populations of rearing coho and chum salmon. The context of such impacts would be important since Crooked Creek and certain reaches of its tributaries are regulated as EFH. This would result in moderate impacts to *off-channel* habitat surface area in the middle reaches of Crooked Creek and minor impacts in lower Crooked Creek.

The intensity of predicted flow reductions that would affect *off-channel* habitat surface area between American Creek and Crevice Creek could be more severe depending on the hydraulic continuity between the streambed and the predicted zone of groundwater drawdown from nearby pit dewatering operations. Based on a *High K* scenario, predicted winter (March) flow reductions during 10th percentile years of low flow in the middle reaches of Crooked Creek could reach a maximum of 85 to 100 percent during Year 20 of operations. During a similar flow

scenario, maximum flow reductions of 40 and 31 percent could occur in Crooked Creek below Getmuna and Bell creeks, respectively. This would result in major impacts to *off-channel* habitat area in the middle and lower reaches of Crooked Creek.

Streamflow Changes and Mainstem Aquatic Habitat

Besides off-channel impacts, predicted streamflow decreases also would reduce the amount of aquatic habitat available in the *mainstem channel* of Crooked Creek. As flows become reduced, the water elevation (stage) would drop thereby decreasing the wetted stream channel surface area. This would cause less aquatic habitat (e.g., pools, runs, and riffles) to be available for fish and benthic invertebrate production. Potential changes in water depth in Crooked Creek during proposed project operations would vary seasonally with the particular phase of mining operations and with the distance downstream from the MSA. Using stage-discharge rating curves and stream channel contour mapping, impacts of flow decreases on aquatic habitat surface area in the mainstem channel of Crooked Creek were estimated for summer and winter season low flow conditions (OtterTail 2015).

Estimates of Crooked Creek habitat loss were predicted based on Year 20, monthly 10-year low flow projections (Table 3.13-27). As described in the sections below, estimates for summer and winter low-flow scenarios provide a high-end (most conservative case) estimate of potential aquatic habitat loss as a result of proposed project operations (however, they did not predict habitat losses corresponding to *High K* scenario flow reductions). On a percentage basis, the greatest reduction in streamflows in Crooked Creek during Year 20 of operations on an annual basis was predicted to occur in *winter* (March) between American Creek and Omega Gulch based on a 10-year low flow scenario (Table 3.5-26 in Surface Water Hydrology). During such time and conditions, streamflows were predicted to be reduced by about 33 percent (BGC 2015c). This would result in impacts of a medium level of intensity as the character and quantity of habitat would be noticeably reduced (Table 3.13-27).

The lowest *summer* streamflows for Crooked Creek typically occur in June. The greatest percentage reduction in Crooked Creek summer streamflows as a result of proposed project operations also was predicted to occur between American Creek and Omega Gulch during Year 20 under a 10-year low flow scenario where flows in this reach would be reduced by a maximum of 25 percent (BGC 2015c). This also would reflect aquatic habitat impacts of a medium level of intensity.

Table 3.13-27 summarizes predicted reductions in aquatic habitat surface area by habitat types (riffles, runs, and pools) by comparing undisturbed summer and winter baseflow conditions, based on a 10-year low flow frequency, with corresponding disturbed conditions during project operations in various reaches of Crooked Creek. Predicted winter and summer changes in water stage and corresponding changes in aquatic habitat types in the mainstem channel are summarized below for specific segments of Crooked Creek.

Winter Streamflow Changes

The lowest annual flows in Crooked Creek typically occur in winter (March). As shown in Table 3.5-26 and based on a 10-year low flow scenario in March during Year 20 of proposed project operations, flow reductions are predicted to range from 25 percent (below Omega Gulch) to 33 percent (below American Creek) (BGC 2015c).

The predicted reduction in Crooked Creek flows, between American Creek and Omega Gulch during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water surface elevation (stage) by 0.13 feet (1.5 inches) resulting in a 5 percent reduction of aquatic habitat (0.44 acres) when all habitat types are considered. Relative to specific habitat types, such a change in water surface elevation would reduce riffle habitat by 12 percent, run habitat by 4 percent, and pool habitat by 3 percent. This also would contribute to a slight reduction in the maximum depth of over-wintering habitat throughout this and other affected reaches of Crooked Creek. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 30.9 cfs to a 10-year low of 9.9 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows vary historically from 14.6 inches to 8.3 inches, respectively, or a reduction of about 43 percent.

The predicted reduction in Crooked Creek flows, between Omega Gulch and Anaconda Creek during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water stage by 0.10 feet (about 1 inch) resulting in an overall loss of aquatic habitat in this stream segment of about 3 percent (0.39 acres). Relative to specific habitat types, this change in water surface elevation was estimated to result in a 6 percent reduction in riffle habitat, a 3 percent reduction in run habitat, and a 2 percent reduction in pool habitat. The maximum depth of over-wintering habitat in this segment of Crooked Creek also would be slightly reduced. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 39.1 cfs to a 10-year low of 12.5 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.4 inches to 6.7 inches, respectively or a reduction of about 50 percent.

The predicted reduction in flows between Anaconda Creek and Crevice Creek, during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water stage by 0.11 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 9 percent (0.72 acres). This reflects a 22 percent reduction in riffle habitat, an 8 percent reduction in run habitat, and a 4 percent reduction in pool habitat. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 43.0 cfs to a 10-year low of 13.8 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.4 inches to 6.3 inches, respectively, or a reduction of about 53 percent.

The predicted reduction in flows in Crooked Creek immediately downstream of Crevice Creek, during Year 20 of proposed project operations under a winter 10-year low flow scenario, would reduce the water stage by 0.11 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 6 percent (2.65 acres). This reflects a 10 percent reduction in riffle habitat, a 5 percent reduction in run habitat, and a 4 percent reduction in pool habitat. Historic undisturbed pre-project flow conditions in this reach reflect winter (March) baseflows that have varied from a monthly average of 48.1 cfs to a 10-year low of 15.1 cfs, a reduction of about 68 percent. Corresponding water surface elevations for these flows have varied from 13.8 inches to 6.3 inches, respectively, or a reduction of about 54 percent.

Summer Streamflow Changes

The lowest summer flows in Crooked Creek typically occur in June. Based on a 10-year low flow scenario during Year 20 of proposed project operations, predicted flow reductions in June

in Crooked Creek from American Creek to below Crevice Creek would range from 11 percent to 25 percent (BGC 2015c).

The predicted reduction in flows in Crooked Creek between American Creek and Omega Gulch, during Year 20 of proposed project operations under a summer 10-year low flow scenario, would reduce the water stage by 0.08 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 3 percent (0.3 acres) with reductions in riffle, run, and pool habitat of about 6, 2, and 2 percent, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 54.3 cfs to a 10-year low of 24.2 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 19.3 inches to 12.6 inches, respectively, representing a reduction of about 35 percent.

The predicted reduction in flows in Crooked Creek between Omega Gulch and Anaconda Creek, during Year 20 of proposed project operations under a summer 10-year low flow scenario, would reduce the water stage by 0.06 feet (or less than 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 2 percent (0.25 acres) with reductions in riffle, run, and pool habitat of about 3, 2, and 1 percent, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 68.6 cfs to a 10-year low of 30.6 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 18.9 inches to 11.8 inches, respectively, representing a reduction of about 38 percent.

The predicted reduction in flows in Crooked Creek between Anaconda Creek and Crevice Creek, during Year 20 of proposed project operations under a summer 10-year low flow scenario, would reduce the water stage by 0.05 feet (or less than 1 inch). The resulting overall loss of aquatic habitat is estimated to be about 3 percent (0.32 acres) with reductions in riffle, run, and pool habitat of about 7, 3, and 2 percent, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 75.6 cfs to a 10-year low of 33.7 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 19.3 inches to 11.4 inches, respectively, representing a reduction of about 41 percent.

The predicted reduction in flows in Crooked Creek immediately downstream of Crevice Creek, during Year 20 of proposed project operations under a summer 10-year low flow scenario, would reduce the water stage by 0.09 feet (about 1 inch). The resulting overall loss of aquatic habitat is estimated to be 4 percent (2.31 acres) with reductions in riffle, run, and pool habitat of about 6, 4, and 3 percent, respectively. Historic undisturbed pre-project flow conditions in this reach reflect summer (June) baseflows that have varied from a monthly average of 82.7 cfs to a 10-year low of 37.2 cfs, a reduction of about 55 percent. Corresponding water surface elevations for these flows have varied from 20.1 inches to 11.4 inches, respectively, representing a reduction of about 43 percent.

Downstream of Getmuna Creek, impacts on Crooked Creek streamflows during proposed project operations would be negligible due to the large inflow contributions from Getmuna Creek and Bell Creek, key tributaries that drain approximately 98.6 mi² and 71.3 mi², respectively. For this reason, impacts on aquatic habitat from potential flow reductions resulting from mining operations were not modeled for the lower reaches of Crooked Creek.

Overall, predicted effects of flow reductions as described above on aquatic habitat in the mainstem of Crooked Creek would occur at a medium level of intensity with the greatest combined impacts to riffle, run, and pool habitat occurring downstream of Crevice Creek. Such impacts would be localized primarily affecting the middle reaches of Crooked Creek near the mine site and would extend over a long-term duration until mine closure. The context would be important since Crooked Creek and certain reaches of its tributaries are regulated as EFH. As a result, predicted streamflow reductions are anticipated to result in moderate impacts to aquatic habitat in the mainstem of Crooked Creek near the mine site with minor impacts in lower Crooked Creek.

If flow reductions in Crooked Creek ultimately reflect a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts to aquatic habitat in the mainstem in both the middle and lower reaches of Crooked Creek would be major.

Streamflow Changes and Salmon Spawning Habitat

Estimated habitat losses from flow reductions can generally result in adverse impacts to both the availability of suitable spawning areas and the viability of eggs incubating in salmon redds¹ during winter, particularly under low flow conditions. Based on the distribution of salmon redds documented in the mainstem Crooked Creek in 2009 by OtterTail Environmental, Inc. (2012e), there would be a medium level of impact intensity to salmon spawning habitat in the lower reaches of the creek (CR-R2 and CR-R1) despite predicted flow reductions in the middle reaches of the mainstem near the mine (CR-R3 and CR-R4). This is primarily due to the large proportion of inflows contributed to the mainstem channel in the lower drainage from Getmuna and Bell creeks. Additionally, salmon redds observed in 2009 were distributed far more abundantly in the lower reaches of Crooked Creek, particularly near the confluence of Getmuna Creek, where proportionally higher baseflows typically occur as compared to reaches farther upstream near the mine (OtterTail 2012e).

Of the 532 salmon redds observed in 2009 during ground surveys along the mainstem Crooked Creek, more than 94 percent were located downstream of Crevice Creek and over 88 percent were located from above Getmuna Creek to the Kuskokwim River (CR-R2 and CR-R1) (OtterTail 2014a). As shown in Table 3.13-6 and Figure 3.13-1, aerial observations from surveys conducted from 2004-2010 documented an annual average of 354 adult salmon in the Crooked Creek mainstem with 314 (88 percent) observed between Crevice Creek and the Kuskokwim River (CR-R3, CR-R2, and CR-R1) and 295 (83 percent) observed from above Getmuna Creek to the Kuskokwim River (CR-R2 and CR-R1). Along the middle reaches of the creek near the mine site (CR-R5 and CR-R4), the observed adult salmon density was considerably lower where an annual average of 40 adult salmon (12 percent) were observed that consisted primarily of coho and chum salmon. Based on these ground and aerial surveys in recent years, salmon distribution has been relatively limited in the middle reaches of Crooked Creek suggesting that the relatively fewer number of redds likely to be distributed along reaches near the mine site would be subject to predicted flow reductions during mine operations.

¹ For this discussion, redds refer to nests excavated by Pacific salmon (i.e., coho salmon, chum salmon, Chinook salmon, sockeye salmon, or pink salmon).

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Table 3.13-27: Estimated Reductions in Aquatic Habitat Surface Area for Summer and Winter Average and Low Flow Conditions during Year 20 of Mine Operations*

Crooked Creek Stream Section	Parameter	Habitat Type	# of Units	Summer				Winter			
				Undisturbed Summer Mapped Discharge Average	Undisturbed Summer (June) Lowflow (10 th Percentile)	Disturbed Summer (June) Lowflow (10 th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow	Undisturbed Winter (Jan) Average	Undisturbed Winter (March) Lowflow (10 th Percentile)	Disturbed Winter (March) Lowflow (10 th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow
Crooked Creek Below American Creek (CCBAM)	Stage (ft)			1.49	1.09	1.01		1.00	0.69	0.56	
	Habitat Area (ac)	Riffles	29	2.70	1.61	1.52	6%	1.51	1.14	1.00	12%
		Runs	55	7.40	6.29	6.14	2%	6.13	5.58	5.35	4%
		Pools	32	3.32	2.94	2.89	2%	2.89	2.71	2.64	3%
		Total	116	13.42	10.84	10.54	3%	10.53	9.43	8.99	5%
	Habitat Area	Riffles	29	20%	15%	14%		14%	12%	11%	
		Runs	55	55%	58%	58%		58%	59%	59%	
		Pools	32	25%	27%	27%		27%	29%	29%	
		Total	116	100%	100%	100%		100%	100%	100%	
Crooked Creek Below Omega Gulch (CCBO)	Stage (ft)			1.45	1.01	0.95		0.91	0.58	0.48	
	Habitat Area (ac)	Riffles	22	2.01	1.15	1.12	3%	1.09	0.90	0.84	6%
		Runs	54	13.35	10.97	10.78	2%	10.67	9.7	9.42	3%
		Pools	19	2.82	2.50	2.47	1%	2.45	2.30	2.25	2%
		Total	95	18.18	14.62	14.37	2%	14.22	12.90	12.51	3%
	Habitat Area	Riffles	22	11%	8%	8%		8%	7%	7%	
		Runs	54	73%	75%	75%		75%	75%	75%	
		Pools	19	16%	17%	17%		17%	18%	18%	
		Total	95	100%	100%	100%		100%	100%	100%	
Crooked Creek Below Anaconda Creek (CCBA)	Stage (ft)			1.46	0.92	0.87		0.87	0.53	0.42	
	Habitat Area (ac)	Riffles	14	3.25	1.04	0.98	7%	1.00	0.67	0.53	22%
		Runs	24	10.64	8.41	8.16	3%	8.25	7.19	6.64	8%
		Pools	3	0.58	0.49	0.48	2%	0.48	0.44	0.42	4%
		Total	41	14.47	9.94	9.62	3%	9.73	8.31	7.59	9%
	Habitat Area	Riffles	14	22%	11%	10%		10%	8%	7%	
		Runs	24	74%	85%	85%		85%	87%	87%	
		Pools	3	4%	5%	5%		5%	5%	6%	
		Total	41	100%	100%	100%		100%	100%	100%	
Crooked Creek Below Crevice Creek (CCAC)	Stage (ft)			1.52	0.99	0.90		0.89	0.53	0.43	
	Habitat Area (ac)	Riffles	64	18.73	10.45	9.77	6%	9.69	6.70	6.01	10%
		Runs	81	53.83	43.19	41.66	4%	41.47	35.67	33.82	5%

Table 3.13-27: Estimated Reductions in Aquatic Habitat Surface Area for Summer and Winter Average and Low Flow Conditions during Year 20 of Mine Operations*

Crooked Creek Stream Section	Parameter	Habitat Type	# of Units	Summer				Winter					
				Undisturbed Summer Mapped Discharge Average	Undisturbed Summer (June) Lowflow (10 th Percentile)	Disturbed Summer (June) Lowflow (10 th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow	Undisturbed Winter (Jan) Average	Undisturbed Winter (March) Lowflow (10 th Percentile)	Disturbed Winter (March) Lowflow (10 th Percentile) 20-year operations	Percent Reduction of Habitat from Lowflow		
				Pools	13	4.22	3.50	3.39	3%	3.38	2.98	2.85	4%
				Total	158	76.78	57.14	54.83	4%	54.54	45.34	42.69	6%
	Habitat Area	Riffles	64	24%	18%	18%		18%	15%	14%			
		Runs	81	70%	76%	76%		76%	79%	79%			
		Pools	13	5%	6%	6%		6%	7%	7%			
		Total	158	100%	100%	100%		100%	100%	100%			
	Total	Habitat Area (ac)	Riffles	129	26.69	14.25	13.38	6%	13.29	9.41	8.38	11%	
			Runs	214	85.22	68.86	66.75	3%	66.52	58.14	55.23	5%	
Pools			67	10.94	9.42	9.23	2%	9.20	8.43	8.17	3%		
Total			410	122.85	92.53	89.36	3%	89.02	75.98	71.78	6%		
Habitat Area		Riffles	129	22%	15%	15%		15%	12%	12%			
		Runs	214	69%	74%	75%		75%	77%	77%			
		Pools	67	9%	10%	10%		10%	11%	11%			
		Total	410	100%	100%	100%		100%	100%	100%			

Notes:
Some totals may not sum due to rounding.
*Source: OtterTail 2014a, predicted changes to streamflow based on BGC 2015c.

Table 3.13-28: Off-channel Habitat Connectivity and Estimated Surface Area for Various Flow Conditions for Mainstream Crooked Creek (2009)

Flow Conditions	Parameter	Reach Description	HAB5 Flat to American	HAB4 American to Anaconda	HAB3 Anaconda to Crevice	HAB2 Crevice to Getmuna ²	HAB1 Getmuna to Mouth ³	Total
Baseflow Minus 16% ¹	Total Area	acres	0.63	1.90	1.47	10.4	3.20	17.60
		hectares	0.2532	0.7696	0.5947	0.42094	1.2959	7.1230
	Units Connected	#	7	11	1	10	2	31
	Area Connected	acres	0.53	1.83	0.82	5.75	2.34	11.27
		hectares	0.2139	0.7396	0.3333	2.3253	.9479	4.5600
	% Connected ⁴	%	84	96	56	55	73	64
Baseflow	Total Area	acres	0.74	2.26	1.75	12.38	3.81	20.95
		hectares	0.3015	0.9162	0.7080	5.0112	1.5428	8.4797
	Units Connected	#	10	11	3	12	3	39
	Area Connected	acres	0.66	2.20	1.75	8.22	2.45	15.29
		hectares	0.2686	0.8907	0.7080	3.3283	0.9918	6.1874
	% Connected ⁴	%	89	97	100	66	64	73
25% Bankfull ¹	Total Area	acres	0.98	3.36	2.36	17.37	5.63	29.70
		hectares	0.3984	1.3596	0.9533	7.0296	2.2778	12.0187
	Units Connected	#	12	13	3	12	3	43
	Area Connected	acres	0.91	3.33	2.36	11.34	3.92	21.86
		hectares	0.3686	1.3477	0.9533	4.5897	1.5869	8.8463
	% Connected ⁴	%	93	99	100	65	70	74
50% Bankfull ¹	Total Area	acres	1.22	4.46	2.96	22.36	7.44	38.44
		hectares	0.4954	1.8029	1.1986	9.0480	3.0128	15.5577
	Units Connected	#	13	14	3	14	3	47

Table 3.13-28: Off-channel Habitat Connectivity and Estimated Surface Area for Various Flow Conditions for Mainstream Crooked Creek (2009)

Flow Conditions	Parameter	Reach Description	HAB5 Flat to American	HAB4 American to Anaconda	HAB3 Anaconda to Crevice	HAB2 Crevice to Getmuna ²	HAB1 Getmuna to Mouth ³	Total
	Area Connected	acres	1.22	4.46	2.96	15.64	5.39	29.67
		hectares	0.4954	1.8029	1.1986	6.3275	2.1820	12.0065
	% Connected ⁴	%	100	100	100	70	72	77
75% Bankfull ¹	Total Area	acres	1.67	6.31	4.31	30.58	10.33	53.20
		hectares	0.6752	2.5539	1.7434	12.3763	4.1814	21.5302
	Units Connected	#	13	14	3	14	3	47
	Area Connected	acres	1.67	6.31	4.31	25.32	7.08	44.68
		hectares	0.6752	2.5539	1.7434	10.2450	2.8658	18.0833
	% Connected ⁴	%	100	100	100	83	69	84
Bankfull ¹	Total Area	acres	2.11	8.17	5.65	38.81	13.22	67.96
		hectares	0.8550	0.33049	2.2882	15.7045	5.3500	27.5026
	Units Connected	#	13	14	3	21	4	55
	Area Connected	acres	2.11	8.17	5.65	38.81	13.22	67.96
		hectares	0.8550	3.3049	2.2882	15.7045	5.3500	27.5026
	% Connected ⁴	%	100	100	100	100	100	100

Notes:

1 Table represents off-channel habitats with connectivity at or below bankfull stage only. A 16 percent reduction represents a flow depletion in Crooked Creek at American Creek (BGC 2011b).

2 Lower portions of reach HAB2 may not experience 16 percent flow reductions due to tributary contributions.

3 Getmuna to the mouth of Crooked Creek would not likely experience a 16 percent reduction in baseflow due to tributary contributions.

4 % Connected = Area Connected/Total Area.

Source: OtterTail 2012e.

Impacts of flow reductions from mine construction and operations on salmon spawning redds were evaluated based on a flow depletion model's predicted conservative estimates of decreases in water surface elevation and known locations and depths of salmon redds as measured during 2009 spawning surveys. The evaluation of flow reduction on spawning habitat determined that 65 percent (11 of 17) of the redds in Crooked Creek between American Creek and Anaconda Creek and 78 percent (7 of 9) of redds between Anaconda Creek and Crevice Creek were located in gravels that would be outside the predicted wetted portions of the stream channel during winter low flow conditions during construction and operations. From Crevice Creek to Getmuna Creek, only 2 percent (3 of 144) of redds observed during the 2009 survey would have been above the predicted winter low flow water line during proposed project operations. Overall, the 21 redds that the flow depletion model predicted would be outside the wetted channel during winter low flow conditions during mining operations represents 4 percent (21 of 519) of the redds observed in 2009 in Crooked Creek below American Creek (OtterTail 2012e).

Donlin Gold modified their proposed project design to include treating and discharging excess water using advanced water treatment. An updated stream flow model showed that the additional discharge had only a minor (positive) effect on the flow depletions; therefore flow reduction impact analyses were not revised.

Such impacts would occur over a long-term duration through the operations phase, reflecting a medium level of intensity that would be detectable and localized to the middle reaches of Crooked Creek near the mine site. The context of such impacts would be important since Crooked Creek and certain reaches of its tributaries are regulated as EFH. Predicted flow reductions in the middle reaches of Crooked Creek would result in moderate impacts to salmon spawning habitat.

If predicted flow reductions of 85 to 100 percent occur in the middle reaches of Crooked Creek reflecting a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts to aquatic habitat in the mainstem in both the middle and lower reaches of Crooked Creek would be major.

Streamflow Changes and Freezing of Spawning Substrates

From late September 2010 to early June 2011, a pilot study was conducted to assess the depth of stream substrate freezing along the mainstem of Crooked Creek between Flat Creek and Getmuna Creek. This study was conducted under low flow conditions and focused on areas where potential salmon spawning would be expected near the tails of pools. Based on the flow conditions observed during the study, substrate freezing was not observed in water depths greater than 1.6 ft. This suggests that potential over-wintering habitat for fish and incubating salmon eggs exists in certain areas of Crooked Creek (OtterTail 2012d).

In the summer of 2009, water depth measurements collected at 532 salmon redds in Crooked Creek during baseflow conditions showed that 68 percent were located in areas where water depths ranged from 1 foot (0.3 m) to greater than 1.6 feet (0.5 m) with minimum depths of redds measured at 4 inches (0.23 m) (OtterTail 2012e; Ottertail 2014a). Regarding redd distribution, 65 percent were located downstream of Getmuna Creek while 92 percent were downstream of Crevice Creek (OtterTail 2012e). According to Hanrahan et al. (2004), the minimum spawning depth for Chinook salmon redds is 11.8 in (0.3 m).

While summer and winter flow reductions up to 25 and 33 percent, respectively, are anticipated in the middle reaches of Crooked Creek near the mine site during Year 20 of operations, overall impacts on salmon redds in the Crooked Creek mainstem are expected to reflect a low level of intensity relative to dewatering or freezing. This is because the majority of observed spawning habitat and adult salmon spawning distribution has been documented to occur in the lower river where predicted winter baseflow reductions during Year 20 of operations would be 10 to 12 percent due to substantial tributary inflows primarily from Getmuna and Bell creeks (BGC 2013f, 2015a). In addition, and as shown in Table 3.13-26, anticipated water stage reductions that would result from predicted flow reductions in the middle reaches of Crooked Creek during Year 20 of mine operations would be less than 1.5 feet. Potential impacts would be localized, primarily involving the middle reaches of Crooked Creek, and would occur over a long-term duration through the operations phase. The context of such impacts would be important since Crooked Creek and certain reaches of its tributaries are regulated as EFH. As a result, predicted streamflow reductions would have minor impacts relative to potential freezing of salmon spawning substrates in the middle reaches of Crooked Creek and negligible impacts in lower Crooked Creek.

If predicted flow reductions of 85 to 100 percent occur in the middle reaches of Crooked Creek reflecting a high level of hydraulic continuity between the streambed and the zone of groundwater depression caused by mine dewatering activities, then anticipated impacts relative to potential freezing of salmon spawning substrates in the middle and lower reaches of Crooked Creek would be major.

Streamflow Changes and Salmon Production

Estimated changes to the flow regime in the Crooked Creek mainstem during construction, operations, and closure are expected to result in a low intensity of impacts on salmon production relative to the overall Kuskokwim River system considering that the Crooked Creek drainage comprises less than 1 percent of the total area of the Kuskokwim River watershed (Wang 1999). Based on 2008 to 2012 weir counts near the mouth of Crooked Creek, the average annual salmon escapement totaled 3,600 fish. The annual averages consisted of 59 Chinook salmon (range 29 to 100); 1,907 chum salmon (range 832 to 3,755); and 1,634 coho salmon (range 591 to 4,204) (OtterTail 2012b).

The extent of predicted flow reduction in Crooked Creek would be primarily limited to the mine site vicinity upstream of Crevice Creek. Even with the proposed supplemental release of treated water to Crooked Creek via the Omega Gulch drainage, the intensity of flow reduction in this area could be severe depending on whether there is a high level of hydraulic conductivity between the streambed and the predicted zone of groundwater drawdown from nearby pit dewatering operations (*High K* scenario). Assuming a low level of hydraulic conductivity, predicted winter (March) flow reduction between American Creek and Crevice Creek during a 10th percentile low flow year scenario, would be 25 to 33 percent during Year 20 of operations. Farther downstream in Crooked Creek and under a similar flow scenario, streamflows are predicted to be reduced by 12 to 10 percent near Getmuna and Bell creeks, respectively.

Flow reductions of this intensity would affect limited populations of spawning and rearing salmon near the mine site. From 2004 to 2010, an annual average of about 40 adult, mostly coho, salmon (12 percent of the total annual average of 354 salmon for these years) were observed

near the mine site upstream of Crevice Creek (Table 3.13-6). The other 88 percent of the adult salmon in Crooked Creek during these years was observed farther downstream between Crevice Creek and the Kuskokwim River.

Based on estimates of aquatic habitat reductions described earlier, predicted flow reductions of 25 to 33 percent in Crooked Creek near the mine site would result in localized impacts of a medium level of intensity relative to salmon production over a long-term duration through the mine operations. The context of such impacts would be important since Crooked Creek and certain reaches of its tributaries are regulated as EFH. As a result, predicted streamflow reductions would have a moderate impact relative to salmon production in the middle reaches of Crooked Creek and a negligible impact in lower Crooked Creek.

Should the underlying geology of Crooked Creek reflect a high level of hydraulic conductivity, flow reductions in Crooked Creek between American Creek and Crevice Creek could be as high as 85 to 100 percent during Year 20 of operations. Farther downstream in Crooked Creek, flow reductions of 40 to 31 percent could occur near Getmuna and Bell creeks, respectively (BGC 2015c). In this case, predicted streamflow reductions of such a high intensity would result in major impacts to salmon production in the middle and lower reaches of Crooked Creek.

While values for the escapement of adult salmon for the entire Kuskokwim River system are not available, since all tributaries are not surveyed or enumerated, annual ADF&G Chinook salmon escapement goals for all 14 monitored tributaries combined were 25,050 to 59,730 (aggregate escapement goal range) (Conitz et al. 2012). By comparison, the average 2008 to 2012 Chinook salmon escapement at the Crooked Creek weir represents between 0.1 and 0.2 percent of the total escapement goal range for all 14 Kuskokwim River stocks for which escapement goals have been established.

Similarly, the average 2008 to 2012 chum salmon escapement past the Crooked Creek weir represents 0.3 to 0.8 percent of the total escapement goal for the four Kuskokwim River stocks for which escapement goals have been established (Conitz et al. 2012). The average 2008 to 2012 coho salmon escapement past the Crooked Creek weir represents 3.4 to 4.9 percent of the total escapement goal for the three Kuskokwim River stocks for which escapement goals have been established (Conitz et al. 2012).

Evaluation of potential impacts to Crooked Creek salmon production, based on predicted flow reductions from the proposed project, in comparison to total salmon production in the Kuskokwim River drainage requires consideration of several factors. First, the escapement goals established for the Kuskokwim River drainage involve salmon stocks from a limited number of tributaries and do not reflect the total abundance from all salmon-bearing streams in the Kuskokwim system. Second, predicted reductions in surface flows, instream habitat quantity and quality, and over-wintering conditions in Crooked Creek due to the proposed project are predominately limited to the middle reaches of Crooked Creek near the proposed mine site and well upstream of lower reaches of Crooked Creek where most spawning occurs. In recent years, spawning salmon densities within the middle reaches of Crooked Creek have been limited whereas most Chinook, coho, and chum salmon spawning has been observed downstream of Getmuna Creek and/or within the Getmuna and Bell creek drainages (OtterTail 2012b). Thus, any percentage comparison of total salmon escapement based on Crooked Creek weir counts versus total escapement goals for the Kuskokwim River system tends to reflect the relative contribution of Crooked Creek stocks which primarily spawn in the lower reaches of Crooked Creek. Therefore, while impacts to Crooked Creek salmon production resulting from predicted

flow reductions would range from moderate to major (depending on whether a *High K* scenario is considered), the context of such impacts relative to total salmon production in the overall Kuskokwim River drainage would be considered minor.

Other Impacts of Streamflow Changes on Aquatic Habitat

American Creek has a catchment area of 6.9 mi² at the confluence with Crooked Creek. During proposed operations, runoff from this catchment would be captured and stored in the lower contact water pond for use in mine operations, thus reducing inflows to Crooked Creek. During Year 20 of operations, the annual average flow to Crooked Creek from American Creek and its adjoining area would be reduced as much as 100 percent due to mining activities (BGC 2011j). Following closure (and when the pit lake fills), flows released from this area could nearly double (due, in part, to discharges from the pit lake) but would annually average 18 percent greater than pre-mining conditions based on average (50th percentile) flow conditions (BGC 2013f).

To limit contact with waste rock, waters upstream of the WRF in American Creek would be diverted into Omega Gulch's relatively small catchment area of 0.9 mi² during the construction and operation phases of mining (BGC 2011j). These diversions may result in average flow increases as large as 287 percent. This likely would result in flow-increase impacts as previously described including bank erosion and channel down-cutting (also refer to section on *Erosion and Stream Sedimentation*). Increased flows in Omega Gulch may alter the distribution and extent of aquatic habitat within the creek channel and in the Crooked Creek mainstem downstream. Depending on the channel's response to increased flows, aquatic habitat and fish passage conditions in Omega Gulch could become altered potentially providing access to areas where fish have not been previously documented (OtterTail 2012b). Potential impacts of this would depend on the nature and extent of changes that could either encourage or deter access and use of instream habitats, particularly in the lower reach of the creek. Flow increases would be temporary, however, as diverted waters would be redirected back to the American Creek drainage during the later years of proposed operations (BGC 2011j).

Construction of the TSF within Anaconda Creek would reduce the watershed area at the confluence of Crooked Creek from 7.7 mi² to 1.8 mi² (BGC 2011j). By Year 20 of mining operations, flows in Anaconda Creek are predicted to be reduced by 24 percent along its remaining segment due to TSF operations (BGC 2013f). Such flow reductions would adversely affect the extent of aquatic habitat as previously described.

During the closure period, surface runoff and in-stream flows in the Anaconda Creek drainage upstream of the reclaimed TSF would be collected and diverted into Crevice Creek by diversion channels. While the average annual flow of Crevice Creek is currently 5.45 cfs, diversion of upper Anaconda Creek would increase the average annual flow in Crevice Creek to 7.79 cfs (by 43 percent) under normal conditions (BGC 2011j). An increase of this magnitude could alter the drainage's configuration to some extent from stream bank erosion and channel down-cutting, in addition to other impacts from flow increases as previously described. Energy dissipating structures would be used to control discharge velocities and streambank stabilization measures would be implemented at select locations where bank scour or excessive down-cutting is anticipated to control effects of erosion and sedimentation.

Lewis Gulch, Queen Gulch, Snow Gulch, and Grouse Creek also may experience flow decreases resulting from pit dewatering activities (BGC 2013f). The effect of these alterations on surface

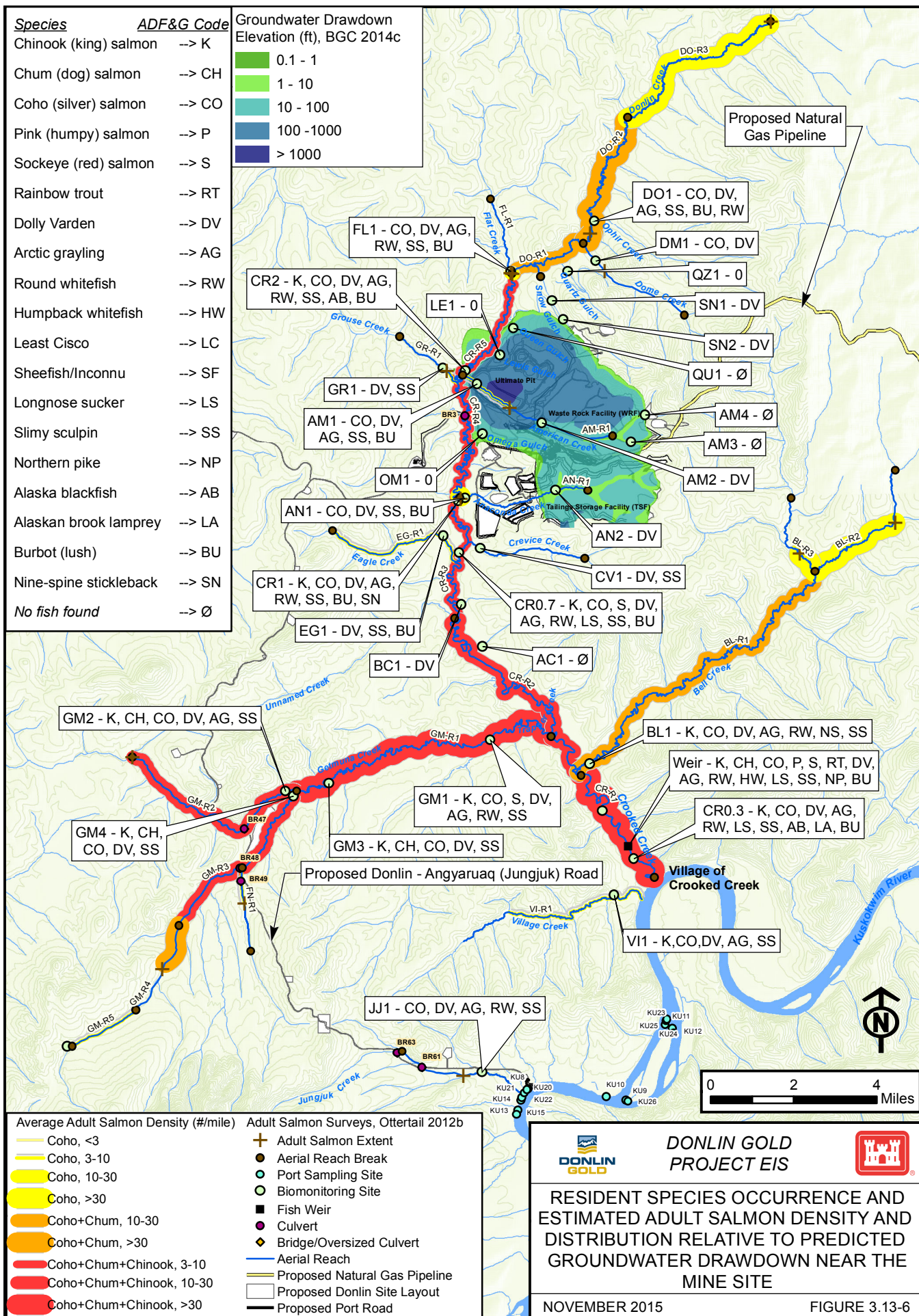
flow in these streams can be predicted based upon the expected drawdown of the water table (Figure 3.13-6). The decreased surface flows would be most pronounced in Lewis and Queen Gulch while flow reductions in Snow Gulch and Grouse Creek would be less.

In addition to flow changes from pit dewatering, Snow Gulch also may be subjected to flow changes based on the operation of the freshwater reservoir. When the process plant would require water withdrawals from the freshwater reservoir to meet its demand, discharges from the reservoir may temporarily cease. This would substantially reduce streamflow to the downstream portions of the creek (AMEC 2011). Depending on the extent of groundwater inflows to Snow Gulch, this could result in a complete diversion of upstream surface flows that would adversely affect Dolly Varden populations downstream of the freshwater reservoir. Establishment of minimum flow releases below the freshwater reservoir could help assure existing populations of Dolly Varden and other aquatic life are sustained.

Stream Temperature Changes

Stream temperature is a measure of the amount of heat energy per unit volume of water. While internal hydrologic processes within the stream system insulate and buffer water temperatures, external factors can alter the amount of heat energy delivered to the stream or the amount of water flowing in the channel. The combination of such internal and external factors can result in a change in a stream's temperature regime. For example, removal of riparian vegetation along stream corridors, human alteration of groundwater dynamics and stream channel morphology, or construction of upstream dams and impoundments with subsequent release of cold hypolimnetic water or warm surface waters to downstream reaches may detrimentally alter the temperature regime of streams (Poole and Berman 2001; Weber-Scannell 1992).

As a primary physical factor influencing the life history of coldwater fishes, temperature affects fish growth and overall survival; changes the timing and distribution of migrating adults as they seek spawning areas; can result in fish avoiding certain streams or stream reaches altogether; and alters the timing for juveniles to become smolts and migrate to salt water (Weber-Scannell 1992; Brett 1952; Jonsson and Ruud-Hansen 1985; Hokanson et al. 1977). Stream temperature directly influences the metabolic rates, physiology, and life-history traits of aquatic species and affects the rates of important community processes such as nutrient cycling and productivity (Allan 1995). Incubation temperatures in a stream above or below a suitable range also will lengthen or shorten the time for egg development, increase egg mortality, and increase the occurrence of deformed fry (Weber-Scannell 1992).



Potential impacts of stream temperature changes resulting from the proposed project were evaluated and determined to be minor, although they vary between the construction and operations and maintenance phases of the mine and the closure phase. During the construction and operations and maintenance phases, stream temperatures in drainages downstream of the MSA are anticipated to remain relatively constant. Both surface water and groundwater from the American Creek and Snow Gulch drainages would be diverted to the mill processing circuit. While this would reduce the volume of flow ultimately reaching Crooked Creek, the amount of heat energy per unit volume of water would not be expected to appreciably change. The possible exception to this would involve a relatively small volume of surface water and pit dewatering well water that would be collected, treated, and discharged to Crooked Creek. The average (50th percentile) proposed surface water diversion and discharge into Crooked Creek would be 1,048 gpm (2.33 cfs) with a range of 2,001 gpm (4.46 cfs) during Year 2 of operations to 756 gpm (1.68 cfs) during Year 25 of operations (BGC 2013f). Based on an average (50th percentile) projection of groundwater pumping, discharge of treated well water to Crooked Creek would be 863 gpm (1.92 cfs). The annual average discharge of treated water from the pit perimeter and in-pit dewatering wells to Crooked Creek over the mine life would range from a high of 1,231 gpm (2.74 cfs) during Year 15 of operations to a low of 0 gpm (0 cfs) during Year 25 and later (BGC 2012b).

While it is likely that treated water from the pit perimeter and in-pit dewatering wells may have a slightly higher temperature than that of the initial untreated water from these sources, the larger contribution of diverted surface water that would be mixed with treated water from the pit perimeter and in-pit dewatering wells before it is discharged to Crooked Creek is expected to result in a negligible change to the Crooked Creek water temperature regime. The average ratio of diverted surface water to treated pit perimeter and in-pit dewatering well water would be 1.21 to 1, with a range over the life of the mine of 0.85 to 1 in Year 15 of operations to 100 percent of the flow originating from diverted surface runoff in Year 25 of operations (BGC 2013f). Although Crooked Creek flows would be reduced due to flow diversions from the upper and lower contact water ponds and Snow Gulch for process water, the net heat energy per unit volume of water is expected to remain relatively unchanged.

Reduced flows in the Crooked Creek drainage during mine operations would affect the thermal mass on a localized basis. While the drainage is currently subject to natural seasonal flow changes and winter freeze, proposed mine operations could further alter the extent and locations in Crooked Creek near the MSA where winter freeze could occur affecting, to a limited extent, the volume and surface area of aquatic habitat available to overwintering fish, aquatic organisms, and their eggs incubating in gravels.

Based on bathymetric contour mapping of the Crooked Creek mainstem between American Creek and Getmuna Creek, undisturbed winter average (50th percentile) flow conditions (typically lowest in January) result in a total surface area of 89.2 acres of aquatic habitat comprised of riffles, runs, and pools (OtterTail 2014a; BGC 2014c). Undisturbed winter low flow (10th percentile) conditions (typically lowest in March) results in a total surface area of 76.3 acres, or a 14.5 percent reduction between undisturbed winter average and low flow conditions. Disturbed winter (March) low flow conditions during Year-20 of proposed mine operations would result in a total surface area of 72.2 acres or a 5.4 percent reduction of aquatic habitat from undisturbed winter low flow conditions. Donlin Gold modified their proposed project design to include treating and discharging excess water using advanced water treatment. In September 2015, the modeled stream flow was updated and had a minor effect on the results.

The analysis of resulting changes in fish habitat effects has not been updated, but the effects would be similar to the previous analysis.

The distribution of reduced winter low flows near the MSA during Year-20 of operations could affect winter freeze conditions. This would vary by location and habitat type between American Creek and Getmuna Creek. Overall through this area, riffle habitat would be reduced from 9.4 acres to 8.4 acres (by 10.6 percent); run habitat would be reduced from 58.4 to 55.9 acres (by 4.3 percent); and pool habitat would be reduced from 8.4 to 8.2 acres (by 2.4 percent). Spatially, the percent reductions of all three habitat types during winter low flows in Year-20 of operations would be greatest between Anaconda Creek and Crevice Creek. In this reach, riffle, run, and pool habitats would be reduced by 22, 8, and 4 percent, respectively. Pool habitat, important to over-winter fish survival, would consist of less than 0.5 acre between Anaconda Creek and Crevice Creek based on the winter average flow as well as both undisturbed and disturbed low flow conditions or about 5 percent of the aquatic habitat in this area. In contrast, 87 percent of this reach consists of run habitat.

The reach between American Creek and just below Omega Gulch consists of 2.7 acres of pool habitat under winter low flow undisturbed conditions or about 29 percent of the habitat in this reach. Flows under Year-20 of mine operations would reduce pool area in this reach to 2.6 acres (by 3 percent) as a result of the water stage being reduced from 0.69 to 0.56 feet. As previously mentioned, Crooked Creek winter stream surveys have not documented substrate freezing in water depths greater than 1.6 feet. In addition, spawning surveys have determined that a small proportion of salmon spawn near or upstream of the MSA where incubating eggs would be at risk from lower flows and winter freeze conditions. From 2004 to 2010, an annual average of 40 adult salmon (12 percent of the total number observed in the mainstem channel) were documented either upstream of the proposed mine site or in the middle reaches of Crooked Creek near the mine where they potentially would have been subject to flow reductions occurring during proposed mining operations.

During summer construction and operation activities, pit de-watering would result in groundwater depressurization near Crooked Creek altering the volume and direction of groundwater flow to and from the creek. Groundwater inflows to a stream channel can moderate water temperature in the channel year-round (Holmes 2000). Reduced groundwater inflows to Crooked Creek could affect the water quality regime (i.e., stream temperatures, oxygen levels, and nutrient concentrations) which, to a certain extent, may locally affect populations of aquatic life (Poole and Berman 2001). Maximum recorded stream temperatures for Crooked Creek at Crevice Creek in June, July, and August are 45.8°F, 51.6°F, and 50.1°F, respectively². Under summer low flow conditions during mining operations, reductions in groundwater inputs to Crooked Creek could cause stream temperatures in reaches near the mine to be close to or above the State of Alaska's water quality temperature standard of 55.4°F for egg/fry incubation and spawning and 59.0°F for migration and rearing. Currently, Crooked Creek's riparian corridor is completely intact providing shade to the stream channel which, to some extent, would help buffer potential mining-related changes to stream temperature. Increases in water temperatures may result in a cumulative increase in degree-day temperature units (TUs), the impacts of which are described below. Such impacts would be most substantial during low-flow events and likely would be localized near the middle reaches of Crooked

2 Unpublished Donlin Gold temperature sensor data provided by BGC Engineering, Inc., May 2009 (BGC 2009b)

Creek, between American and Crevice creeks, where riffle habitat and salmon spawning is limited (OtterTail 2012b; OtterTail 2014a).

Following mine closure, a post-closure water treatment plant (WTP) would be constructed prior to the pit completely filling. Treatment would begin in Post-Closure Year 52 to maintain the operating level of the lake at elevation 316 feet. This would provide sufficient freeboard and storage for upset flood events and also would prevent a groundwater gradient from developing that might otherwise cause groundwater in the vicinity of the pit lake to migrate toward Crooked Creek. After the pit lake fills to the operating level, the warmer surface water would be treated and monitored to meet compliance standards and discharged directly into Crooked Creek during the April through September open water season.

The post-closure phase of the project likely would result in seasonal water temperature changes in Crooked Creek due to the transition of the American Creek drainage from a cold water stream environment to flows influenced by releases from the pit lake via the WTP (reservoir environment). Waters draining from the surface of reservoirs tend to have higher temperatures than nearby streams due to longer residence time and increased solar exposure. Downstream of dams and reservoirs, warming waters have been shown to cause shifts in macroinvertebrate communities, increased fish species richness, and reductions in population densities of certain coldwater fish species (Lessard and Hayes 2003).

Fish, macroinvertebrates, and other aquatic life would be potentially affected by a warmer water temperature regime in the Crooked Creek drainage during the post mining closure and reclamation phase. Section 3.7, Water Quality, provides additional information on water temperature changes anticipated during this phase of the proposed project. A direct effect on salmon would involve the cumulative increase in degree-day TUs experienced by incubating salmon eggs in response to warmer temperatures from treated discharges released from the pit lake.

The development of salmon eggs through egg hatch and egg sac absorption is temperature dependent and normally expressed in TUs. One TU represents 1 day that the mean daily water temperature exceeds freezing by one degree; 1 day with a mean water temperature of 36°F (2°C) represents 2 Celsius degree-day TUs. Salmon stocks have genetically evolved to maximize survival over a wide geographic area and climatic conditions. The dates of initial spawning and subsequent egg development and hatch reflect an adaptation to and synchronization with watershed-specific temperature regimes (Quinn 2005). The timing of seasonal spawning migration and other life-cycle stages in Pacific salmon populations is often highly adapted to local thermal conditions in freshwater rivers, streams and lakes, and the ocean. Adaptation and natural selection in response to water temperature changes can shape the timing of migration so it more favorably aligns with environmental conditions that avoid predictable periods when stressful, energetically demanding, or dangerous conditions occur (Kovach et. al. 2012; Hodgson and Quinn 2002).

Increasing water temperatures in a southeast Alaska stream, where yearly mean temperature anomalies were elevated by about 36°F (2°C) over a 40-year period, have been shown to result in the earlier timing of migration and spawning of a pink salmon population by nearly two weeks (Kovach et. al. 2012). Increasing water temperatures also have been shown to affect the timing of egg development, maturation, and emergence of freshwater fishes (Weber-Scannell 1992). Salmon stocks may be adversely affected if earlier egg hatch and alevin emergence does not coincide with favorable river or stream conditions. As a result, genetic selection would favor

fish that adapt to the new temperature regime provided water temperatures do not exceed critical survival thresholds (Kovach et. al. 2012).

The median number of Celsius degree-day TUs typically required for Chinook salmon to hatch is 542 (range 485 to 569°C TUs) while 1,056 are required (range 912 to 1,201°C TUs) for emergence. For coho salmon, the median number of °C TUs required for eggs to hatch is 521 (range 425 to 577°C TUs) with 927 required (range 641 to 958°C TUs) for emergence. The median number of °C TUs required for chum salmon eggs to hatch is 538 (range 365 to 641°C TUs) with 888 (range 732 to 1,138°C TUs) for emergence (Weber-Scannell 1992).

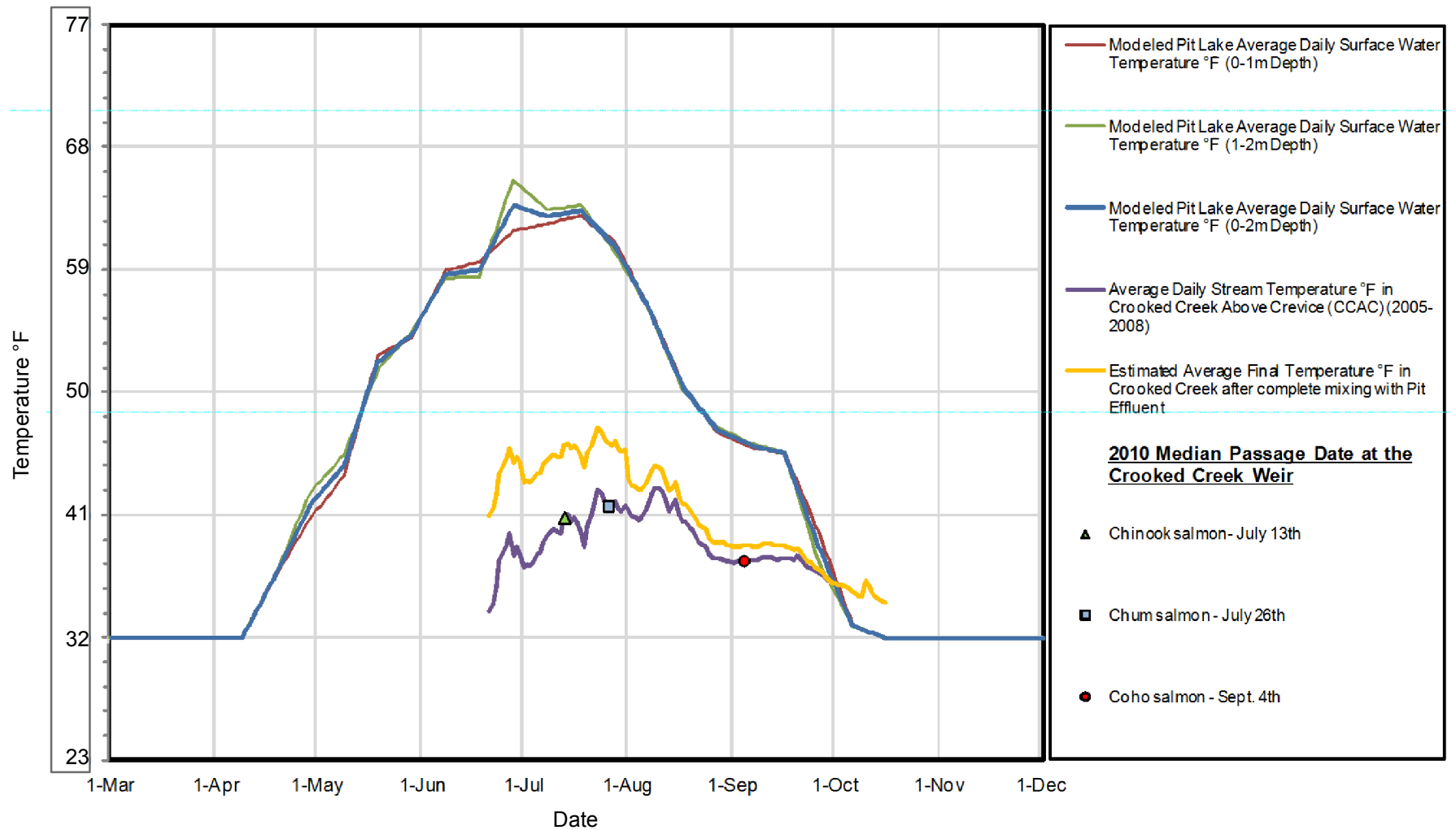
Pit lake water surface temperatures were modeled for post-closure discharges after the pit lake reaches its operating level. As shown in Figure 3.13-7, the average daily water surface temperatures (0 to 6.6 feet deep) for the pit lake during an average flow year (50th percentile) are predicted to be highest from mid-June to late July, peaking at approximately 63.7°F (17.6°C) on June 28th³. Over this same period between 2005 and 2008, water in Crooked Creek downstream of Crevice Creek had an average daily temperature of 39.6°F (4.2°C)⁴. Based on water balance models, treated water from American Creek is predicted to contribute, on average, 13 percent of the Crooked Creek flow at its confluence with American Creek during the April through September open water season when discharge would occur. This percentage may be expected to fluctuate over time based on seasonal variations in precipitation and the water storage available in the pit lake. Predicted water temperatures and resultant TUs were calculated for the mixed maximum WTP pumping rate of 6,605 gpm (14.7 cfs) and the 10-year low flow (10th percentile) in Crooked Creek. The resultant water temperature of the blended flow was evaluated for its effect on the stream temperature in Crooked Creek immediately downstream from the American Creek and Crevice Creek confluences.

The predicted increase in TUs was evaluated using 1) modeled daily pit lake water temperatures; 2) measured daily water temperatures in Crooked Creek between 2005 and 2008; 3) anticipated dates of discharge from the pit lake; and 4) the median dates of salmon migration in Crooked Creek. Median dates of migration were determined based on the passage of salmon past the Crooked Creek weir located 1.5 miles upstream of the Crooked Creek confluence on the Kuskokwim River (OtterTail 2012b). In 2010, the median dates for salmon migration past the weir were July 13 for Chinook salmon; July 26 for chum salmon; and September 4 for coho salmon (OtterTail 2012b). The median date represents the period in time when 50 percent of the migration would have passed the weir; although actual egg deposition on the spawning grounds likely would have occurred at a later time.

Under this scenario, the predicted increase in Celsius degree-day TUs is 156.4°C TUs for Chinook salmon; 93°C TUs for chum salmon, and 18.5°C TUs for coho salmon following the median passage date at the downstream weir. As noted, this is a conservative estimate and would likely be lower because salmon passing through the downstream weir would not yet have begun spawning and depositing eggs. This represents approximately 14.8 percent of the total °C TUs required by Chinook salmon to emergence; 10.5 percent of the total °C TUs to emergence for chum salmon; and only 2 percent of the total °C TUs to emergence for coho salmon. These values are within the normal range presented above for chum and coho salmon and just slightly above the normal range for Chinook salmon.

3 Unpublished data provided by Lorax Environmental Inc., May 2009 (Lorax 2009)

4 Unpublished Donlin Gold temperature sensor data provided by BGC Engineering, Inc., May 2009 (BGC 2009b)



Data Source: Ottertail 2012a



**DONLIN GOLD
PROJECT EIS**



**MODELED AVERAGE SURFACE
WATER TEMPERATURE FOR THE
PIT LAKE (AVERAGE FLOW YEAR -
50TH PERCENTILE)**

NOVEMBER 2015

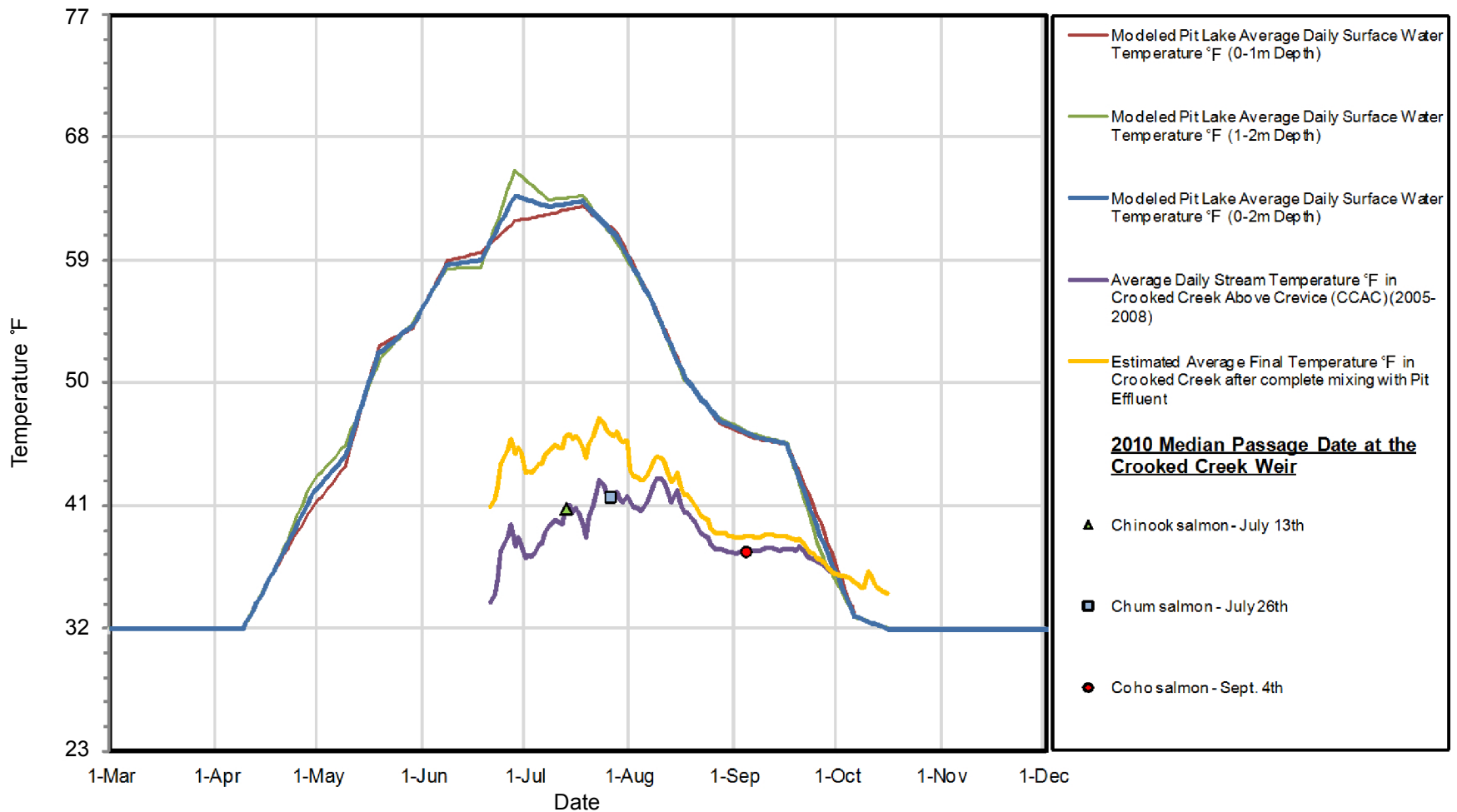
FIGURE 3.13-7

Most Chinook and chum salmon spawning in Crooked Creek occurs in the lower river downstream of Crevice Creek (OtterTail 2012b, 2012d) where additional tributary inflows would buffer potential impacts of discharges with elevated temperatures from the pit lake. Based on the modeled maximum pit lake discharge (Figure 3.13-8) and 10-year low flow conditions in Crevice Creek, the predicted increase in °C TUs in Crooked Creek, downstream of Crevice Creek, would be 107.4 for Chinook salmon; 63.3 for chum salmon; and 12.6 for coho salmon. Such increases remain well within the documented normal range of TUs for Chinook, chum, and coho salmon. As a result, potential alterations to the temperature regime would have an overall minor effect on Chinook or chum salmon fry production. Under the 10-year (10th percentile) low flow scenario, the maximum TUs increase in Crooked Creek downstream of Crevice Creek is 10.2 percent of the average amount required to reach emergence for Chinook salmon and 7.1 percent of that needed to reach emergence for chum salmon. Although coho salmon spawn in Crooked Creek immediately downstream of American Creek, the predicted temperature increase under this scenario is still likely to result in a minor adverse effect because of the extremely limited number of additional TUs (1.4 percent of total needed to reach emergence) that might be accumulated during the anticipated discharge period.

Water temperatures within Crooked Creek would return to baseline levels when discharge from the pit lake ceases each year at the end of September. As such, no additional accumulation of TUs above natural background levels would be expected after discharge from the pit lake ceases. Average water temperature during the first two weeks of October 2006 was 35.4°F (1.91°C).⁵

Salmon that deposit their eggs in gravels in mid- to late summer/fall exhibit embryonic growth under a declining water temperature regime with emergent fry produced in early spring. The earliest stages of development at which embryos can tolerate low temperatures and grow normally reflect adaptive spawning times among salmon populations. The early blastula stage (128-cell development) is the first developmental stage that displays tolerance to temperatures below the optimal threshold 40.1 to 42.4°F (4.5 to 5.8°C) (Combs and Burrows 1957; Combs 1965). Fertilized eggs of Chinook salmon require 144 hours at 42.4°F (5.8°C) to develop to the blastula stage (Groot et al. 1995). This temperature corresponds favorably with the modeled average water temperature of 42.4°F (5.8°C) predicted to occur downstream of Crevice Creek between July 15 and July 31. In addition, some evidence indicates that a modest water temperature increase early in the egg incubation period (through early blastula or 128-cell stage) may increase subsequent egg survival during colder water periods (Combs 1965). As a result, the intensity of impacts of predicted stream temperature changes on fish and other aquatic biota would be localized and range from low to medium. The duration of impacts would be permanent with an important context since Crooked Creek and certain of its tributaries are regulated as EFH. Therefore, impacts to fish and other aquatic biota from stream temperature changes in Crooked Creek near the MSA would range from minor to moderate while minor impacts are expected in lower Crooked Creek below Crevice Creek.

5 Unpublished data provided by BGC Engineering, Inc., June 2009 (BGC 2009c)



Data Source: Ottetail 2012a



DONLIN GOLD
PROJECT EIS



MODELED AVERAGE SURFACE
WATER TEMPERATURE FOR THE
PIT LAKE (10-YEAR LOW FLOW -
10TH PERCENTILE)

NOVEMBER 2015

FIGURE 3.13-8

Erosion, Stream Sedimentation, and Metals Emissions

Erosion and Stream Sedimentation

Proposed mining activities have the potential to release particulates and sediment into local drainages and tributaries from a range of activities and sources including:

- soil disturbance, compaction, and vegetation removal;
- wetland in-filling that reduces sediment retention and exposes soils to erosive forces of wind and/or water;
- stream erosion from increased flows released as a result of inter-basin diversions and transfers;
- rock fracturing/processing activities; and
- runoff from constructed roads, runways, and materials sites.

Sections 3.2, Soils; 3.5, Surface Water Hydrology; and 3.7, Water Quality provide additional information on soil disturbance, erosion risk, and related impacts on water quality at the proposed mine site during construction, operation, and closure.

Development, operation, and closure of the proposed mine and its infrastructure can introduce additional particulates and sediment loads to local drainages. Increased sediment has been shown to degrade the quality and quantity of aquatic habitat by elevating suspended solids and increasing turbidity (Waters 1995). Sediment generated from natural, catastrophic, and anthropogenic sources can fill interstitial spaces of substrates within a stream channel which, in turn, can decrease habitat important to fish spawning, egg incubation, and rearing.

Excessive erosion and sedimentation can affect the survival of incubating fish eggs; reduce substrate cover and refugia habitat for fish rearing and migration; increase predation of fishes; cause a loss of winter carrying capacity; and decrease the availability of habitats that support an abundant and diverse macroinvertebrate community and sources of food for fish (Waters 1995; Bjornn and Reiser 1991; NMFS 2011a). Excessive sediment loads also can affect the morphology of stream channels and the availability, distribution, quality, and functions of habitats important to fish and other aquatic life. While sediment transport and deposition are natural stream processes, major disruptions of the stream system and its functions may occur when sediment delivery is substantially changed or when the ability or capacity of the stream to transport sediment is altered.

Erosion and sedimentation also may elevate turbidity which can adversely affect fish feeding behavior and growth and reduce tolerance to disease and toxic compounds (Waters 1995). While salmonids, at times, may avoid or delay migration in waters with high silt loads (Cordone and Kelley 1961; Bjornn and Reiser 1991), they also commonly migrate as adults or juveniles through the mainstems of the Kuskokwim, Copper, Tanana, and other rivers that are characteristically turbid throughout the open water season (Lloyd et al. 1987).

Elements of the proposed mine development, operations, and reclamation phases that could result in the release of varying amounts of particulates and sediment to Crooked Creek drainages include the WRF, overburden stockpiles, pits, TSF, stormwater management systems, mine access roads, culverts, runways, general construction practices, water diversions and conveyance systems, and gravel/material sites. Proposed project activities at the mine site will

result in the disturbance of approximately 9,000 acres of surface soil. The potential amount of stream sedimentation that would result from such disturbance will depend on the effectiveness of BMPs ultimately implemented and maintained during all phases of the project.

Depending on the effectiveness of control measures implemented, weather conditions, and site issues encountered, potential unanticipated impacts could occur that generate increased sediment loads in Snow Gulch; Omega Gulch; and Crooked, American, Anaconda, and Crevice creeks. In the Snow Gulch drainage, construction and operation of the freshwater reservoir would alter sediment transport and stream sedimentation downstream of the proposed dam. The freshwater reservoir would act as a settling basin by intercepting fine sediments from the upper drainage and preventing the natural delivery of sediments to the lower reaches of the creek. While retention of fine sediments in the reservoir may reduce turbidity downstream and provide more efficient foraging for fish; the reduced sediment load may increase the stream's potential to erode its banks and down-cut the channel downstream.

An Erosion and Sediment Control Plan (ESCP) and SWPPP will be prepared during final design for specific elements of the mine site area. Proposed BMPs described in these plans will be finalized in accordance with ADEC, Division of Water requirements. The plans will be prepared during the final design and permitting phase of the project to reflect construction and engineering design changes and potential regulatory comments from the NEPA review process.

Proposed BMPs include sediment and stormwater management and monitoring measures that would be implemented from initial construction of mine infrastructure through mine closure. Sediment control measures include silt fences, hay bales, sediment retention basins, cross bars and ditches, runoff interception and diversion, mulching and revegetating disturbed surfaces and soil stockpiles. Other BMPs included in these plans are designed to reduce the intensity of surface runoff, erosion, particulates, and sediment loads in downstream drainages. BMPs would be installed and monitored to ensure their effectiveness and minimize impacts to fish, other aquatic biota, and their related habitats. Post-closure sediment controls would include site grading and capping of erodible material, revegetation, and re-routing of surface runoff to reestablish natural conditions.

For local drainages near the mine site directly affected by construction and operation activities, sedimentation could adversely affect aquatic habitat within tributaries and in Crooked Creek over the long-term at a low to medium level of intensity. Impacts of a medium level of intensity are anticipated when extreme weather events coincide with ground disturbance activities, grading, and major excavations. The context of effects would be important since Crooked Creek, American Creek, and Anaconda Creek are regulated as EFH. As a result, anticipated impacts of erosion and sedimentation on fish and aquatic habitat in the middle reaches of Crooked Creek would be minor to moderate with negligible impacts in lower Crooked Creek.

Metals Emissions

The potential for risk to fish and aquatic organisms from particulates released from mine operations on surrounding land and water was evaluated for mercury, arsenic, antimony, and other metals. Mercury is naturally present in the environment and associated with gold deposits such as those in the Kuskokwim Gold Belt where the proposed MSA is located. Methylmercury, which is formed when mercury combines with carbon, is readily absorbed by living organisms, is persistent in the environment, and has high toxicity and bioaccumulation characteristics. Gaseous mercury released from non-point sources could be transported from the processing

facilities or TSF to local drainages. An analysis was conducted that evaluated potential impacts of mercury dispersion on the environment from proposed construction and operational activities (SRK 2014a; ARCADIS 2014). Based on the analysis, it was determined that:

- Most mercury from ore processing will be captured and contained;
- Mercury in ore processing air emissions would be the largest source of mercury;
- Mercury sediment concentrations could increase from 2.5 percent above current baseline concentrations at Donlin Gold Camp to 0.8 percent above baseline at Village Creek;
- Surface water concentrations in Crooked Creek watershed could increase, but would remain below Alaska water quality criteria; and
- Concentrations of mercury in fish in the Crooked Creek watershed could increase, but the changes would likely be low (up to 3 percent above current levels) and within the range of regional background fish tissue concentrations. The level of increase would depend, however, on whether the future bioavailability of mercury to fish would be similar to historic conditions.

An analysis of potential environmental effects of metals from dust deposition on wildlife resources (see Section 3.12.2.2, Wildlife) resulted in the conclusion that dust deposition would increase the concentrations of mercury, antimony, arsenic, and other metals but by very low percentages that would not be expected to pose an additional risk to biota beyond that occurring from existing baseline concentrations.

With respect to mercury, mining activities in the Crooked Creek drainage under Alternative 2 would contribute additional inputs of total mercury to surface waters and wetland systems from atmospheric and aqueous sources on a long-term basis extending from construction through mine closure and reclamation. While aqueous sources of mercury could affect water quality in local streams and wetlands downgradient of mine construction and operations activities, atmospheric sources could distribute mercury to regional drainages up to 10 miles from the mine site area. Additional information on potential impacts of mercury and other selected metals from fugitive dust sources during proposed mining activities is described in Section 3.2, Soils and Section 3.7.3.2.2, Surface Water Quality.

It is anticipated that only a small fraction of the inorganic mercury dispersed from the mine site would be available for methylation (Marvin-Dipasquale et al. 2009). Combined sources from mining activities, however, could result in measurable increases in total mercury that exceed the 12 ng/L chronic effects criterion for aquatic life. Non-migratory fish and aquatic prey species that reside in the Crooked Creek watershed, considered common to area drainages, would be more subject to the bioaccumulation of methyl mercury than non-resident migratory species such as salmon.

Dust deposition resulting from construction, operation, and closure would affect soil quality at a low level of intensity, since anticipated increases for mercury and antimony would not reach levels of concern. Arsenic, however, is expected to exhibit a small increase (up to 5 percent) above naturally high baseline concentrations. While baseline concentrations of arsenic are more than an order of magnitude higher than ADEC levels, the additional sources of arsenic that could be mobilized by the mine would contribute a relatively small increase in soil concentrations over the life of the project. Planned mitigation measures for dust control are expected to minimize the levels of these effects and are described in Chapter 5, Impact

Avoidance, Minimization, and Mitigation. Anticipated effects would be long-term, potentially accumulating and persisting over the life of the mine, and would remain at similar or reduced levels following mine closure. Soil quality effects are considered common in context, in that the soils affected are regionally extensive, and it is unknown whether they would be subject to future ADEC oversight due to potential dust impacts.

In the Crooked Creek drainage, or other watersheds where elevated levels of mercury naturally occur, wetland disturbance or in-filling can result in the transfer of methylmercury from sediments to down-gradient receiving waters allowing it to be available for assimilation by prey and predatory species of fish and other aquatic life. Alterations to the rate of mercury methylation in wetland systems in the mine site area from proposed construction and mining activities would depend upon several factors including:

- the presence or expansion of environments with no or limited levels of oxygen;
- the presence of sulfate-reducing or iron-reducing bacteria;
- the availability of multi-modal transfers of mercury (from air, water, or soils);
- the nutrient status of wetland systems (e.g., the availability of organic carbon, inorganic nitrogen, and sulfur); and
- the pH of sediments and soils.

As described in Section 3.7.3.1.1, Water Quality, the methylation potential near the mine site was evaluated along with potential consequent changes in project-related mercury concentrations and methylation rates (ARCADIS 2014). The main conclusions from the analysis are that negligible methylation occurs in most rivers and streams where water is actively flowing. Additionally, the intensity and extent of methylation in area wetlands was determined to be low and is not expected to increase from mine activities.

Average methylmercury concentrations in surface waters, however, have been predicted to increase at a medium level of intensity, from 0.280 ng/L to 0.398 ng/L (42 percent increase over the baseline concentration), due to mining activities proposed under Alternative 2 (ARCADIS 2014). The duration of increased methylmercury concentrations in surface waters and wetlands would be long-term, with concentrations expected to return to pre-activity levels after project closure. The geographic extent of this would be considered regional due to the potential for aquatic habitats outside of the immediate project area to be affected from deposition of atmospheric mercury sources. Since atmospheric sources of mercury could extend to streams and wetlands in the region regulated as EFH, the context of such effects would be important.

Because the applicable numeric water quality criterion for methylmercury is expressed as a fish and shellfish tissue concentration, rather than a surface water concentration (EPA 2010a), methylmercury concentrations in surface water predicted to result from proposed mining activities under Alternative 2 cannot be compared to regulatory limits. Site-specific bioaccumulation factors (BAFs) can be used to explain and predict the relationships between methylmercury concentrations in primary media, such as surface water or sediment, and the concentrations measured in fish tissue. Because site-specific BAFs that are required to explain methylmercury relationships between water and fish tissue are not presently available for the areas that would be subject to mercury dispersion from fugitive dust and water under Alternative 2, recommendations for conducting fish tissue monitoring to develop such site-specific BAFs are described in Chapter 5 (Impact Avoidance, Minimization, and Mitigation).

Additional information on potential impacts on the environment from releases of mercury is presented in Section 3.24, Spill Risk.

Based on the above information, potential impacts to fish and aquatic habitat from erosion, stream sedimentation, and metals emissions would be minor to moderate within the MSA, the Crooked Creek drainage, and nearby watersheds in the region.

Summary of All Mine Site Area Impacts

Near the mine site, direct and indirect impacts on fish and aquatic resources, including long-term to permanent effects on EFH, are anticipated in the middle reach of Crooked Creek as a result of altered flow regimes, reductions in instream habitat, and loss of off-channel habitat and connectivity between the mainstem and off-channel areas. Such impacts would result from flow diversions and other water management activities in the mine site area, pit dewatering, and clearing, earth movement, and grading along certain Crooked Creek tributaries. Variable levels of effect would occur during construction, operations, and closure. During construction and operations, the intensity of adverse impacts from reductions in habitat and flow in the middle reaches of Crooked Creek would range from low to high. This would primarily affect rearing Chinook and coho salmon and spawning coho salmon. The most substantial proportion of adult salmon escapement and production occurs in lower Crooked Creek, Getmuna Creek, and Bell Creek. Flows in Getmuna and Bell creeks would be unaffected by mine site activities. In lower Crooked Creek, the intensity of adverse impacts from flow reduction during Year 20 of operations would be low during winter low flow periods for average and low-flow years. Potential impacts from anticipated flow reductions in Crooked Creek would be minor relative to broader populations of fish in the Kuskokwim River.

A summary of potential impacts for the overall mine site involve the following:

- In-stream habitat removal and disturbance or loss of fish and benthic biota: Permanent impacts would occur to about 8 total miles of stream habitat within five drainages along the eastside of the Crooked Creek watershed from construction, operation, and closure of the proposed mine and its infrastructure. Affected tributaries would include Snow Gulch, Lewis Gulch, American Creek, Omega Gulch, and Anaconda Creek. American Creek would experience the greatest loss of aquatic habitat (about 4 miles) where populations of about 4,300 fish, primarily consisting of Dolly Varden, have been estimated. The intensity of habitat alterations, surface flow diversions, behavioral disturbances, and fish mortalities within these drainages would range from medium to high. For the most part, tributaries directly affected by filling, grading, and flow diversions or reductions contain aquatic habitats, fish, and other aquatic species common to the Crooked Creek watershed. Impacts associated with American and Anaconda creeks would have an important context, however, since the lower reaches of these drainages are regulated as Anadromous Water for coho salmon rearing by ADF&G and as EFH supporting key life stages of salmon. As a result, minor to moderate localized impacts are anticipated for tributaries in the MSA that are directly affected by habitat loss and flow reduction while a minor level of corresponding impacts is anticipated in lower Crooked Creek downstream from Crevice Creek to the Kuskokwim River confluence where most Chinook, coho, and chum salmon spawning and production occurs.

- Water management practices: During mine construction and operation, water pumped from the in-pit and perimeter wells (about 1,400 gpm) will be treated according to APDES permit requirements and ADEC water quality standards with nearly one third of the flow conveyed to the mill processing plant and two thirds discharged to the Crooked Creek drainage. Collecting and diverting other up-gradient non-contact surface waters from local drainages in the MSA around mine operations and then to tributaries and Crooked Creek downstream would result in localized impacts of a medium intensity to aquatic habitat and fish populations near the mine site.

Most of the tributaries directly affected by filling, flow diversions, and other water management practices would experience permanent losses of aquatic habitats, fish, and other aquatic species common to the Crooked Creek watershed. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks have an important context since these waters are regulated as EFH supporting key life stages of salmon that are of high importance to the Kuskokwim subsistence community. While moderate to major impacts are anticipated in the affected tributaries and middle reaches of Crooked Creek, minor impacts are anticipated to lower Crooked Creek except under a *High K* scenario where major impacts are anticipated from the middle reaches of Crooked Creek to the Kuskokwim River.

- Water quality practices: All mine contact water will be retained and re-used on site for mill processing throughout mine operations, thereby avoiding water quality impacts on aquatic resources in the Crooked Creek drainage. After mine closure when the pit fills, water from the pit would be treated per APDES permit specifications and applicable ADEC water quality standards to ensure protection of aquatic life before being discharged to the Crooked Creek drainage. During and following closure, water quality compliance monitoring would continue at all points of discharge based on requirements established during final design and permitting after the NEPA process is completed. As a result, the intensity of water quality impacts to fish and aquatic species in the Crooked Creek drainage as a result of treated water discharges is anticipated to be low. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would have an important context since these waters are regulated as EFH supporting key life stages of salmon and are of high importance to the Kuskokwim subsistence community. A minor level of impact is anticipated in the middle and lower reaches of the Crooked Creek drainage.
- Wetland and riparian buffer removal: Removal, grading, and filling of vegetation, wetland communities, and riparian buffers due to mine development would reduce or degrade aquatic habitat at a local scale within several drainages east of Crooked Creek. Drainages directly affected would experience permanent impacts of a medium to high intensity from reduced surface water infiltration, retention, and groundwater flow; increased surface water runoff; and reduced water quality functions (e.g., binding of nutrients, metals, and sediments from surface runoff). Such impacts would be attenuated to a low level of intensity downstream from the MSA in the lower reaches of Crooked Creek due to tributary inflows. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to

Donlin Creek; and Getmuna and Bell creeks would have an important context since these waters are regulated as EFH supporting key life stages of salmon and are of high importance to the Kuskokwim subsistence community. A moderate level of localized impact is anticipated in drainages directly affected within the MSA while minor impacts are expected in lower Crooked Creek.

- Streamflow changes and overall aquatic habitat: The intensity of direct and indirect impacts on flows and aquatic habitats in tributaries affected by mine operations and in Crooked Creek near the MSA is anticipated to range from low to high. Predicted flow reductions would be greatest in winter months (November to April) in the middle reaches of Crooked Creek from American Creek to below Crevice Creek. During the winter of Year 20 of operations under 10-year low flow conditions, flows in this reach are predicted to be reduced from about 33 to 25 percent while, during closure, flows would be reduced by about 10 to 13 percent. Alterations of winter low-flow levels during Year 20 of operations would affect riffle, pool, and run habitat by reducing the combined total area of these habitats by about 5 percent between American Creek and Omega Gulch and by about 9 percent from below Anaconda Creek to below Crevice Creek.

Based on aerial surveys of spawning adult salmon conducted from 2004 to 2010, an annual average of about 350 salmon have been observed in the mainstem of Crooked Creek with 88 percent of the observations occurring between Crevice Creek and the Kuskokwim River where flow reductions from mine operations and closure would be minor. Over this same period in the middle reaches of Crooked Creek upstream from Crevice Creek, an annual average of 40 adult salmon (12 percent of the total) were observed primarily consisting of coho and chum. This indicates that the relatively small proportion of redds annually produced in this reach over this period would have been subjected to reduced flows had the proposed mine been operating.

The geographic extent of impacts associated with flow reductions and aquatic habitat alterations in the Crooked Creek mainstem would primarily extend from the confluence of Queen Gulch to below Anaconda Creek. The impact intensity in the lower reaches of Crooked Creek and in the Kuskokwim River would be low due to substantial inflows from undisturbed Getmuna and Bell creek drainages. Impacts on surface flows in the affected tributaries and in the middle reaches of Crooked Creek would be permanent, extending beyond the life of the project. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would have an important context since these waters are regulated as EFH supporting key life stages of salmon that are of high importance to the Kuskokwim subsistence community. In the middle reaches of Crooked Creek, the level of impacts to fish and aquatic habitat resulting from streamflow changes would be moderate while minor impacts are expected downstream in lower Crooked Creek. Under a *High K* scenario, impacts to fish and aquatic habitat in the middle and lower reaches of Crooked Creek would be major.

- Stream temperature changes: Reduced groundwater inflows to Crooked Creek resulting from in-pit and pit perimeter dewatering wells could affect the water quality regime (i.e., stream temperatures, oxygen levels, and nutrient concentrations) which, to a certain extent, may locally affect populations of fish and aquatic life (Poole and Berman 2001).

Under summer low flow conditions during mining operations, reductions in groundwater inputs to Crooked Creek could cause stream temperatures in reaches near the mine to be close to or above the State of Alaska's water quality temperature standard of 55.4°F for egg/fry incubation and spawning and 59.0°F for migration and rearing. In the middle reaches of Crooked Creek, this may result in a cumulative increase in degree-day temperature units (TUs), affecting the duration and timing of egg incubation and availability of prey species. Such impacts would be most noticeable during low-flow events and likely would be localized between American and Crevice creeks, where riffle habitat and salmon spawning is limited. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks would have an important context since these waters are regulated as EFH supporting key life stages of salmon that are of high importance to the Kuskokwim subsistence community. In the middle reaches of Crooked Creek, a minor to moderate level of impact from stream temperature changes is anticipated while a minor level of impact is expected downstream in lower Crooked Creek.

- Erosion and stream sedimentation and metals emissions: Unless effectively controlled, sediment generated from several sources at the proposed mine site could be released to tributaries and the mainstem channel of Crooked Creek in the MSA. The magnitude and extent of stream sedimentation in these drainages will depend on the effectiveness of BMPs ultimately implemented and maintained during all phases of the project. BMPs and other environmental management procedures described in an ESCP and SWPPP will be finalized and implemented in accordance with ADEC, Division of Water requirements. These plans will be prepared in the final design phase to reflect construction and engineering changes and regulatory comments from the NEPA and permitting review processes.

The performance of sediment control measures implemented from these plans would be monitored throughout the life of the project to ensure potential impacts to fish, other aquatic biota, and related habitats are avoided or minimized. Even with such controls, some localized stream sedimentation could be measureable particularly when extreme weather events coincide with ground disturbance activities, grading, and major excavations from construction through reclamation phases. Where and when this might occur, impacts could be of a low to medium intensity (altering the local character and quality of aquatic habitat) in tributaries and receiving waters immediately downstream. Impacts involving the lower reaches of American and Anaconda creeks; the mainstem of Crooked Creek from its mouth to Donlin Creek; and Getmuna and Bell creeks have an important context since these waters are regulated as EFH and support key life stages of salmon that are of high importance to the Kuskokwim subsistence community. In the affected tributaries and middle reaches of Crooked Creek, moderate to minor levels of impact are anticipated while negligible impacts are expected farther downstream in lower Crooked Creek. The dispersion and deposition of metals and formation of methylmercury concentrations in aquatic habitats in the MSA would have a low to medium level of impact intensity compared to baseline concentrations. As a result, a moderate to minor level of impact on fish and aquatic habitat is anticipated near the MSA and in the Crooked Creek watershed.

3.13.3.2.2 TRANSPORTATION FACILITIES

Potential impacts from transportation infrastructure elements of Alternative 2 would result from construction of the airstrip and Angyaruaq (Jungjuk) Port site and periodic deliveries of cargo and fuel by tug and barge traffic on the Kuskokwim River and from Dutch Harbor to the Port of Bethel over the 110-day annual shipping season. Potential impacts also would result from construction and maintenance of the access road, bridges, and culverts for stream crossings between the Angyaruaq (Jungjuk) Port site and the mine site, and from the removal of rock and gravel from the materials sites.

Water Transportation

Under Alternative 2, general cargo and fuel required for the construction, operation, and closure phases of the proposed mine would be transported along the Kuskokwim River from offshore marine waters and Kuskokwim Bay to the Port of Bethel, then to the proposed Angyaruaq (Jungjuk) Port site. Additional shipments would continue upriver to barge landings located beyond Stony River to support construction of the gas pipeline crossings. The marine transportation fleet operating on these waters would be subject to all applicable state, federal, and international statutes and regulations administered and monitored by the U.S. Coast Guard and other regulators. Additional information and analysis related to barge operations is presented in Sections 3.23, Transportation and 3.5, Surface Water Hydrology.

While tug and barge combinations on the Kuskokwim River from Bethel to Crooked Creek currently consist of approximately 68 round trips per year (involving mostly medium-size tows comprised of a single tug pushing one- to two-barges), the majority of existing vessel traffic involves smaller, high-speed boats that often travel closer to the river bank than slower barge traffic.

In addition to existing vessel traffic, project-related barge traffic for cargo and fuel shipments would occur over the 110-day ice-free shipping season typically extending from June 1 to October 1. During the 4-year construction phase and subsequent 27.5-year operations phase, commercial barge traffic would travel from the Port of Bethel upriver approximately 168 miles to the Angyaruaq (Jungjuk) Port site averaging about 122 cargo and fuel barge tows (round trips) per season. This would represent a 180 percent increase in barge traffic over existing levels. River barge tow configurations and loading, which affect vessel maneuverability and draft, would be determined based on the average daily discharge and associated depths and widths of the river channel. Depending on the elevation (stage) of the river, fuel barge tows in this section of the river would involve two or four barges configured side to side with a draft of 3 to 7.5 feet. During the mine closure and reclamation phase, project-related barging would be minimal with traffic returning to near baseline levels. In addition, the Angyaruaq (Jungjuk) Port facilities would be removed and reclaimed leaving only a limited barge landing to support long-term monitoring activities.

As described below, several mechanisms associated with increased tug and barge traffic could result in potential impacts on fish and aquatic resources. While the nature of cargo and fuel shipments transported by ocean and river vessels would be similar for the various action alternatives, the number of fuel barges and trips and the quantity of fuel delivered to the Angyaruaq (Jungjuk) Port site would vary. Refer to Chapter 2, Alternatives, and Section 3.23, Transportation, for additional information related to waterway transportation.

Several approaches have been incorporated into the River Barge Fleet Design and Operation Plan to reduce potential impacts of vessel traffic and fuel or chemical spills on the Kuskokwim River and those who rely on it for transportation and other uses (AMEC 2013). These include:

- Maximizing the cargo capacity and draft of barges within the constraints of river navigability and safety to minimize the number of barge trips each shipping season;
- Adopting double-hull fuel barge designs for the fuel barge fleet;
- Designing a barge operations system that does not require river dredging;
- Building port facilities at the Angyaruaq (Jungjuk) Port site to reduce the length of overland road route to the mine site;
- Using special ISO containers for the transport of cyanide;
- Implementing a two-way communications strategy with local communities regarding schedules and current status of barge traffic; and
- Adopting current best practices for the transport, handling, and storage of fuel and hazardous and dangerous goods including site-specific strategies for initial cleanup response.

General Cargo Shipments

As described in the River Barge Fleet Design and Operation Plan (AMEC 2013, 2014), general cargo would be shipped by ocean tugs and barges from consolidation terminals in Seattle, Washington or Vancouver, BC to the region's main port in Bethel about 73 nautical miles up the Kuskokwim River. Over the 4-year construction period, 40 ocean barge trips would be used to deliver about 230,000 tons of construction cargo to Bethel where the cargo would be unloaded at a newly constructed 16-acre terminal for temporary storage on the dock or transferred to smaller barges for upriver transport. The barge fleet and terminals throughout the Kuskokwim River would operate on a 24 hours/day, 7 days/week basis. About 200 river barge trips (50 per year) would be required to deliver cargo from Bethel to the upriver port site over the 4-year construction period. Some of these would involve delivery of equipment and supplies for pipeline construction to the staging areas on each side of the Kuskokwim River at the pipeline crossing about 100 miles upriver from Angyaruaq (Jungjuk) Port.

Because the Kuskokwim River freezes in winter, the shipping season at the mouth of the river would be restricted each year to the ice-free period that typically begins between late May and June 1st and extends through September. A 2007 study based on a review of satellite data by Triton Consultants Ltd. determined that ice clearance at the river mouth has been as early as May 1st and as late as early June over the past 10 years. As a precautionary measure, the shipping window for barging cargo upriver from Bethel has been planned to occur over 110 days from June 1st to September 9th.

Fuel Shipments

The first fuel shipments from Pacific Northwest refineries would leave for Dutch Harbor in early May traveling in 6.5 Mgal capacity double-hull ocean barges. At Dutch Harbor, fuel would be pumped ashore to 13 Mgal capacity storage facilities (8 Mgal of which might need to be constructed, but without additional changes to waterfront structures, to support the

proposed project) until being delivered to Bethel by a 2.94 Mgal capacity double-hull ocean fuel barge. At Bethel, fuel would be off-loaded for temporary storage at the existing fuel terminal (requiring 10 Mgal of the existing 19 Mgal capacity) or transferred directly to double-hull river barges for delivery to the Angyaruaq (Jungjuk) Port site. From here, fuel would be off-loaded to a temporary 2.6 Mgal capacity storage tank and later transferred to tanker trucks for delivery to the 37.5 Mgal capacity mine site fuel storage facilities (sufficient for 10 months of fuel consumption during operations). Similar to the cargo shipping season, fuel barges entering the river mouth each year would be limited to the ice-free period that typically begins in late May to June 1st and extends through September. For fuel barges traveling upriver from Bethel, the shipping window plan also was limited to 110 days typically extending from June 1st to September 9th. During the construction period, an average of 15 fuel barge trips per year would be required; 3 of which would go to the pipeline crossing of the Kuskokwim River.

Direct and Indirect Impacts

Waterway shipments of fuel and cargo to the mine would increase Kuskokwim River barge traffic from baseline levels of about 68 round trips to approximately 122 (average) to 190 (peak) round trips per season. Potential impacts related to the increased barge traffic on fish and aquatic resources primarily would result from vessel-induced wave energy, propeller turbulence, and possible temporary vessel groundings. At certain times and locations, increased barge traffic also may periodically affect small-boat traffic routing and subsistence fishing activities. In addition, incidental spills of fuel could occur at port facilities or along the waterway or roadway corridor to the mine site.

Depending on the water depth, channel geometry, and riverbed character at critical sections of the river and the timing, speed, and specific route of travel of barge traffic, potential direct and indirect impacts could result from:

- Bank erosion and riverbed scour that cause direct habitat disruption and increased suspended sediment concentrations and turbidity;
- Displacement or stranding of young-of-year fish along certain shallow-gradient riverbanks and bars;
- Increase in risk for aquatic invasive species introduction and spread affecting fish and aquatic habitats;
- Behavioral disturbance to resident and anadromous fish life stages (migration, rearing/feeding, and spawning); and
- Propeller strikes or shear forces causing fish injuries or mortalities or alteration of fish behavior and migration.

Note that in the Kuskokwim River, spawning habitat disruption from dislodging of eggs or sedimentation can result from natural flooding, ice break up, bank erosion, and riverbed scour (from both natural causes and boat/barge traffic).

To evaluate potential impacts, several mechanisms were considered based on peer-reviewed literature and field investigations. These included potential effects of:

- Vessel waves on bank failure, erosion, suspended sediments, and turbidity that could cause gill abrasion, respiratory stress, feeding and behavioral disturbance, and disease susceptibility in aquatic life;
- Vessel waves on river temperature regimes near the confluence of tributaries along the margins of the mainstem channel;
- Vessel waves on fish displacement and stranding along certain shallow-gradient river banks and gravel bars;
- Tug propeller forces on injury or mortality of fish life stages, river bed scouring, and critical habitat; and
- One or more of the above mechanisms in combination with past, existing, or reasonably foreseeable future impacts from other non-project origins (see cumulative impacts analysis in Chapter 4).

In addition to the above, potential impacts of vessel traffic on subsistence fisheries (net management and riverbank use/access) and the accidental release of transported fuel or chemicals are described in Section 3.21, Subsistence, and 3.24, Spill Risk, respectively.

The spatial and temporal distribution of resident and anadromous fish life stages were considered in this analysis relative to habitat conditions and use along the main navigation channel of the Kuskokwim River. For example, the location and timing of fish use, migrations, and movements were evaluated relative to potential areas of risk, particularly where barge traffic would pass through confined and shallow segments of the river channel and near the confluence of major tributaries (BGC 2013i, 2015m; AMEC 2014). At Nelson Island, near the confluence of the Tuluksak River, the available channel width of the Kuskokwim River would be only 129 feet when low flow period approach about 39,000 cfs and when the water depth would be about 5 feet (see Section 3.5.2.2.3, Surface Water Hydrology, Table 3.5-21).

The relative importance of tributaries for salmonid spawning and rearing also was considered since adults and juveniles are commonly distributed in these waters where potential effects from tug and barge traffic would be negligible. Geographically, potential effects of shallow-draft barge traffic on fish and their migrations in the Kuskokwim River primarily would involve certain segments of the main navigation channel between the Port of Bethel in the lower river and the proposed Angyaruaq (Jungjuk) Port site (168 nautical miles upriver).

Vessel Wave Energy

Vessel-generated waves (wakes), drawdown and surge (from water displaced by large vessels in transit), and propeller turbulence (prop wash) create hydraulic forces that can actively alter water quality and other physical, biological, and chemical attributes of the shore zone in lakes, rivers, and coastal ecosystems. In rivers, the extent of channel alteration by such vessel forces is largely influenced by the magnitude of flow, geometry of the channel relative to vessel geometry and draft, and character of the shore zone as defined by river bed substrates, shoreline profile, and in-water and upland vegetation and soils.

The height, speed, and frequency (period) of vessel waves are key parameters that affect the magnitude of erosive forces that encounter a shore zone (Corps 2000a). These parameters are primarily controlled by a vessel's speed, although the vessel's size, distance to shore from its sailing line, and hull design/geometry also are key factors affecting wave height (Gates and

Herbich 1977). Hodek et al. (1986) concluded that controlling speed is the most effective way to reduce vessel-caused erosion along shorelines. Shore zones that are seasonally subjected to natural high-energy events including wind, flooding, and ice-out conditions may largely consist of coarse-textured substrates with limited ability to generate additional suspended sediment concentrations when subjected to vessel waves on a periodic but long-term basis (Corps 2000a).

Hydraulic forces generated from vessel waves and propulsion systems in confined and shallow channels can potentially affect the shore zone when vessels pass at relatively high speeds. Other factors that contribute to effects of wave forces on shore zones include the vessel's draft, hull geometry, and propulsion system; the channel's depth and configuration; and composition and character of streambed substrates and other instream structure. A vessel with a hull design/geometry that occupies a large proportion of the channel cross-section will cause wave heights to increase markedly. Frequent, short-term exposure to vessel waves in such areas can result in shore zone erosion and bed scouring, re-suspension and transport of sediments, and failure of bluffs and riverbanks (Corps 2000a). According to Mazumder et al. (1993), navigation traffic on large waterways can generate wave energy and turbulence that cause substantial temporary changes in water velocity with the largest changes taking place in a zone that extends about 10 percent of the channel width from shore. An important aspect of a vessel's hull geometry that affects wave generation is the shape and dimensions of the bow and stern. Vessels of comparable bow and stern geometries but with different parallel mid-body lengths produce waves of the same magnitude (Helwig 1966). This suggests that barge tows with similar bow and stern geometry but different lengths should generate waves of a similar magnitude that would be subsequently altered by the character of the shore zone.

Sediments in river systems remain suspended in the water column in the case of fine-textured particles (i.e., suspended sediment) or, because of their larger size, settle out and become deposited along the river bed and banks. Settled sediments become temporarily re-suspended and transported downriver when flow conditions mobilize medium to fine-textured materials along mid-channel and point bars and in backwater areas. The quantity and distribution of in-channel sediment sources that provide habitat for fish and other aquatic biota are strongly influenced by hydrologic forces that shape the character and stability of the riverbed and banks. Typical non-channel sources of sediments that may be transported to rivers include upland soils mobilized by runoff, bank failures and landslides, and development activities that cause shoreline disturbance.

On the Kuskokwim River, key factors affecting bank erosion and channel scour are natural flooding caused by spring breakup and intense precipitation during the open-water season. Compared to flooding, wave energy from wind or vessel traffic has less influence on river erosion rates largely due to the width of the river in most areas (BGC 2007c, 2013i). Most of the existing vessel traffic along the Kuskokwim River involves small, high-speed boats that often travel closer to shore than more infrequent, slower, and larger tug and barge combinations. Waves from small-boat traffic traveling close to shore have been observed to result in larger and more frequent waves along the shoreline than barge traffic (Camfield et al. 1980). This suggests that, at certain times and locations, small-boat traffic may create conditions that contribute to bank erosion more than large-vessel traffic.

To evaluate how project-related barge traffic could affect shorelines along the Kuskokwim River, estimates were developed that predicted the maximum height of vessel-generated waves that could result from upriver and downriver fuel and cargo barge traffic at five representative

reaches along the Kuskokwim River mainstem where the channel width is confined (BGC 2013i, 2015m; AMEC 2014). The reaches investigated were located near Aniak, Kalskag, Tuluksak, Akiak, and Akiachak. Calculation of absolute vessel speed was a key component of the analysis. Upriver absolute vessel speed was defined as the vessel speed *plus* the average river velocity (from June to mid-September for the five reaches evaluated) whereas downriver vessel speed was defined as the vessel speed *minus* the average river velocity for these reaches.

Depending on the reach evaluated, upriver (loaded) fuel and cargo barge traffic was predicted to travel at absolute vessel speeds that varied from 8.7 feet per second (fps) at Aniak to 10.1 fps at Akiak (5.2 to 6 knots or 5.9 to 6.9 mph, respectively). This resulted in minor wave heights of 0.6 to 1.3 inches in these respective reaches. In comparison, unloaded downriver-bound barge traffic was predicted to travel at absolute vessel speeds that varied from 13.6 fps (8 knots or 9.3 mph) at Akiak to 14.1 fps (8.4 knots or 9.6 mph) at Aniak. This resulted in waves that ranged from 4.6 inches at Tuluksak to 8.9 inches at Aniak. Wave heights would be expected to decrease for barge traffic farther downriver, particularly where the channel widens and is deeper and where vessel traffic travels farther from shore. Wave height predictions could be similarly developed for other reaches of the river based on calculations of absolute vessel speed that would be required to navigate a channel of a known geometry at a given distance to shore from the line of vessel travel.

Wave-generated hydraulic forces from small boats and barge traffic traveling near the margins of the Kuskokwim River where high levels of fine-texture sediment have not been previously disturbed by natural flooding and ice-out conditions could cause riverbank erosion that reduces water quality by elevating suspended sediment concentrations and turbidity. The anticipated magnitude of such impacts along the margins of the mainstem channel could range from low to high, depending on such factors as speed of vessel transit and proximity to shore, width of the river, channel geometry, and the availability of fine-textured substrates that could be mobilized.

Water quality degradation from increased levels of suspended sediment and turbidity has been shown to adversely affect the survival and growth of early life stages of fish and other aquatic life in rivers and streams (Barrett et al. 1992). This may be caused by impairing the ability of fish to capture prey and/or avoid predation along migration corridors or nursery areas. Reduced feeding efficiency and avoidance behavior have been documented by exposing juvenile coho salmon, accustomed to relatively clear waters, to elevated levels of turbidity exceeding 70 nephelometric turbidity units (NTU), well below sublethal stress levels (Bisson and Bilby 1982). Juvenile salmon and other prey species accustomed to waters with low turbidity have been shown to avoid areas with unacceptably high levels of turbidity (Servizi 1988). In contrast, fish have been shown to seek out waters having moderate levels of turbidity (10 to 80 NTU) that can provide visual protection and cover from predators (Cyrus and Blaber 1987a, 1987b). Although a reduced preference by adult salmon homing to spawning areas has been demonstrated where turbidities exceed 30 NTU (20 mg/L suspended sediments), Chinook salmon exposed to 650 mg/L of suspended volcanic ash have been able to locate their natal waters (Whitman et al. 1982).

Fish and benthic macroinvertebrates are generally tolerant of suspended sediments and turbidity up to the point of reaching relatively high levels that can cause abrasive injuries, clog gill tissues, impede respiratory functions, and cause mortalities to incubating eggs and larvae and benthic food sources (Robertson-Bryan, Inc. 2006). Pacific salmon and trout fingerlings exposed to suspended solids levels of 300-750 mg/L have been documented to survive 3-4

weeks even with short daily increases to 2,300-6,500 mg/L (Griffin 1938). Based on a literature review by Van Oosten (1945), average suspended solids concentrations of up to 200 mg/L were found to be tolerable to fish which were shown to thrive in waters with total suspended solids levels over 400 mg/L. While conducting surveys of rearing fish on the Kuskokwim River in July 2014, turbidities at Kalskag, Birch Tree Crossing, and Holukuk were determined to average 84, 101, and 150 NTU, respectively (Owl Ridge 2014f). These and other studies suggest that effects of suspended sediments and turbidity on a given species of fish can vary widely, depending upon the texture of sediments and the intensity of exposure (Robertson-Bryan, Inc. 2006).

Potential effects of barge-generated waves, riverbank erosion, and turbidity on the quality of shallow-gradient nearshore nursery habitats used by larval and juvenile life phases of resident fish, seaward migrating salmon, and invertebrate prey species would depend on the location, intensity, frequency, and extent of wave exposure along margins of the river that are subject to erosion. Juvenile salmon in the Kuskokwim drainage predominantly rear in tributaries and, therefore, would largely be unaffected by turbidity generated from barge traffic until they travel downstream into mainstem river channel where they rear while migrating to sea. As previously described, studies by BGC (2015m) have predicted that wave heights from passages of barge traffic would be minor for upriver traffic and less than 9 inches in height for downriver traffic. Based on the level of riverbank erosion that occurs in the mainstem Kuskokwim River from natural flooding and ice-out conditions and considering naturally high background levels of turbidity that exist, the intensity of nearshore erosion and turbidity that could be attributed to vessel passages along the navigation route could range from unmeasurable to low in response to intermittent episodes of small waves generated over a long-term duration extending from construction through the operations and maintenance phase. The extent of potential wave exposure would be local, mostly limited to confined channel segments between the lower Kuskokwim River and the upriver port site. The context of such impacts would be important since the river's mainstem is regulated as EFH. As a result, anticipated impacts from vessel wave forces on nearshore erosion, suspended sediment levels, turbidity, and fish rearing habitat quality would be minor.

Water temperature in the Kuskokwim River was evaluated relative to potential impacts from barge traffic in a study by OtterTail Environmental, Inc. (2012e). Results of the study concluded that mixing of water by vessel passages does not cause notable changes in the water temperature profile in the main channel which was found to be generally well mixed and unstratified. While small changes in water temperature were observed before and after vessel passage, the differences were within the range of natural temperature variation measured in the water column. These findings are consistent with Wetzel (2001) who reports that thermal stratification is typically uncommon in river systems where water is constantly mixing.

Although not evaluated in the Ottertail Environmental, Inc. study described above, tributary confluences or side channels with a different thermal character than the main river channel could contribute to localized variability in water temperature. During certain times of the year, shallow, shore zone margins and backwater areas that may be influenced by groundwater upwelling may be occupied by juvenile fish as they seek waters with low velocity and higher dissolved oxygen for feeding, refuge, or migration (Winkler et al. 1997; Keckeis et al. 1997). Water temperature in such areas, combined with prey availability and abundance, can determine the growth potential and mortality rates of juvenile chum salmon (Mason 1974; Healey 1982a; Salo 1991). Depending on the character and location of such areas relative to the Kuskokwim River navigation channel, vessel passages could generate wakes and turbulence

sufficient to temporarily alter the local water temperature regime, particularly near tributary confluences or backwater areas during the June to September barge season.

Monitoring nearshore water temperature during barge passages in confined channel segments and near tributary confluences would provide an improved basis for determining whether local water temperature regimes in certain shore zone areas would be substantially altered whereby refuge or rearing functions for outmigrant salmon juveniles and other resident fishes would become degraded. The anticipated intensity of such impacts is uncertain at this time but likely could be low over an intermittent yet long-term duration that would extend from construction through operations. The extent of potential impacts would be local, involving certain nearshore waters of confined river segments or downstream from tributary confluences between the lower Kuskokwim River and the upriver port site. The context of such impacts would be important since the mainstem and its tributaries are regulated as EFH since they provide conditions that support key life stages of five species of Pacific salmon. As a result, anticipated impacts from vessel wave forces on nearshore water temperature and fish rearing habitat is anticipated to be negligible to minor.

Fish Displacement and Stranding

Studies involving the Lower Columbia, Mississippi, and other large rivers suggest that, under certain conditions, ship wakes produced by deep-draft vessels can displace and sometimes strand fish along shorelines (Pearson et al. 2006; Entrix 2008; FERC 2008; Corps 2000a; Kucera-Hirzinger et al. 2009; Ackerman 2002). Although not evaluated in association with smaller, shallow-draft vessels such as barge tows, fish stranding from passages of deep-draft vessels has been generally observed along shallow, low-gradient shorelines where young-of-year fish are swept to shore onto exposed beaches or shallow pools isolated from the main channel. The susceptibility of young-of-year fishes has been shown to be related to their inability to swim against strong currents, including those from wakes of deep-draft vessels (Wolter and Arlinghaus 2003). Stranding can result in mortality unless the fish are swept back into the water by a subsequent wake. Pearson et al. (2006) noted that fish stranding strictly occurred during nighttime vessel passages and that no stranding occurred at the same locations during daytime passages.

Fish stranding has been shown to be associated with a series of interconnected factors that are not fully understood (Pearson et al. 2006; FERC 2008). As a result, it is not possible to accurately predict whether a vessel of a particular size and hull configuration, traveling at a given speed, water depth, and distance from shore, through a channel of a certain width and geometry would cause fish stranding. Vessel speed of travel, however, is considered the key factor controlling the height of a wave produced from a passing ship while distance to shore from the sailing line and hull design also are important (Gates and Herbich 1977).

Young-of-year and older juvenile riverine fishes occupying shorelines can be subject to displacement from vessel-generated hydraulic forces (Kucera-Hirzinger et al. 2009; Wolter et al. 2004; Winkler et al. 1997; Keckeis et al. 1997). Such forces can be caused by drawdown and surge (from displacement of water by a vessel in transit), vessel wakes, and propeller turbulence. These forces can combine to increase water velocities to a level along the shoreline that may cause small-size, fish to be displaced to deeper waters or washed ashore (Arlinghaus et al. 2002; Hucksdorf et al. 2011). Pearson et al. (2006) found that only small, young-of-year Chinook fry were stranded by waves from deep-draft vessels on the lower Columbia River

while larger and stronger age 1+ fish (with greater swimming ability) appeared capable of withstanding the stronger currents and were not stranded. Chronic, intermittent exposure of young-of-year fish to increased velocities and displacement, even at relatively moderate levels, has been found to adversely affect growth and increase physiological stress which may contribute to the decline of certain fish stocks (Kucera-Hirzinger et al. 2009; Flore et al. 2001). Although passing barge traffic could cause nearshore rearing fish to be subject to long-term chronic exposure to intermittent episodes of increased velocities from vessel wakes and propeller forces, recent Kuskokwim River studies have shown that juvenile salmon rearing primarily occurs in backwater areas and tributaries unaffected by barge traffic until these fish enter the main channel for seaward migration (Owl Ridge 2015b).

In 2010, a study was conducted on the Kuskokwim River to assess potential stranding mortalities of seaward migrating salmon smolts as a result of waves from local barge traffic (OtterTail 2010). Shorelines were monitored at select gravel bars in the lower Kuskokwim River. Although the selected survey sites were known to be occupied by juvenile fish and subject to wave forces, they were not located in the more confined segments of the river above Aniak. In addition, the monitored shorelines were known to be periodically occupied by migrating smolts that travel near the water surface. Although the waters evaluated were subject to frequent waves from barge traffic, no evidence of fish stranding or mortality was observed. Results of the study showed that wakes, generated by the particular tug-barge configurations that were in transit during the study were less than 1.5 inches in height along the gravel bars surveyed. This suggests that comparably powered and configured upriver-bound barge tows with similar drafts, traveling at similar speeds and distances from gravel bars having a similar character and orientation, could generate wakes of a relatively low intensity that result in no or minimal risks to salmon smolt stranding. Larger barge tow configurations powered by tugs with a higher horsepower rating, deeper drafts, and traveling downriver at higher speeds, however, may generate wakes of magnitudes that could pose risks to juvenile salmon along river margins in certain areas.

As previously described, unloaded barge tows returning downriver from the Angyaruaq (Jungjuk) Port site traveling at absolute speeds of up to 14.1 fps (8.4 knots or 9.6 mph) were predicted to generate waves up to 8.9 inches in height near Aniak (BGC 2015m). Wave heights of this magnitude that extend to the shore zone, particularly in confined channel segments with shallow-gradient shorelines, could produce currents capable of temporarily displacing small young-of-year salmon or small resident fishes rearing or migrating along the shore zone. In particular, chum and pink salmon begin their downriver migrations to estuaries at a small size and remain longer in brackish waters than other salmon species such as Chinook and coho salmon (Healey 1982b; Simenstad et al. 1982; Fukuwaka and Suzuki 2002). Their relative small size, limited swimming ability, and longer residence along river and estuarine shorelines during their seaward migration tend to make young-of-year chum and pink salmon vulnerable to wave forces, especially in critical river sections with confined channels and shallow nearshore waters. Five such critical sections of the Kuskokwim River have been identified where available channel widths would range from 129 to 576 feet when average daily flows approach 39,000 cfs with minimum channel depths of 5 feet (AMEC 2014). Progressing upriver, these sections were located at Nelson Island (near the confluence of the Tuluksak River), Birch Tree Crossing, Aniak, Holokuk, and Upper Oskawalik.

Between May 15 to June 1 and June 19 to 22, 2015, surveys were conducted at relatively confined channel segments of the Kuskokwim River near Birch Tree Crossing and above Upper

Kalskag to assess the timing and distribution of juvenile salmon during their seaward spring migrations. The survey sampled river habitats with seines (effort: 336 seine passes/48,738 linear m/1,297,792 m³ of water). The catch, which was highest in mid-May through June 1 and decreased considerably by the third week of June, consisted of 21,752 small chum salmon, 428 coho, 196 sockeye, 81 pink, and 45 Chinook salmon. Most fish were collected along river margins consisting of shallow shoals and backwaters within a few feet of shore (Owl Ridge 2015b). While barge wakes were not present during the survey, fish that were collected occupied shallow waters that could be subject to wave forces from passing vessels. Sixty-eight percent of chum salmon smolt were captured in areas deemed susceptible to barge wake and 32 percent in areas not susceptible to barge wake. Furthermore, 39.5 percent of the chum smolt measured at potential barge wake areas were large enough to avoid stranding (>40 mm). Based on the length of the young-of-year salmon captured and the locations and patterns of habitat use observed, barge-wakes of sufficient magnitude could have displaced or possibly stranded young-of-year salmon, particularly those observed along shorelines with low-gradient shoal habitat. However, barge wakes of sufficient magnitude to cause stranding (>1 foot) are not expected. Depending on the location and channel configuration where barge wakes or tugs could encounter abundant distributions of juvenile salmon along river margins between ice break-up into late June, potential incidents of stranding or displacement could be detectable at a low intensity. The timing of such impacts would be seasonal and intermittent and would extend over the long-term during the construction and operations phases. Such impacts would be local, occurring along certain reaches of the river, and of an important context involving the mainstem Kuskokwim River that is regulated as EFH. As a result, anticipated impacts from vessel wave forces on fish displacement and stranding would range from negligible to possibly moderate in confined channel segments.

In late May of 2014, a survey of rainbow smelt migration and spawning was conducted where smelt were observed along the river margins in large concentrations within 20 feet of shore. Spawning was determined to occur in waters at a mean depth of 8.5 feet (range 5 to 10 feet) upstream from upper Kalskag (Owl Ridge 2014a). In a similar study conducted in 2015, rainbow smelt also were observed migrating along shorelines where they spawned in late May. Unlike the 2014 survey, spawning occurred at locations downriver from lower Kalskag in a narrower river segment and at a deeper mean depth of 14.5 feet with a range of 8.7 to 23.4 feet (Owl Ridge 2015a). Since adult rainbow smelt reach lengths of up to 12 inches, their swimming ability at this size would be sufficient to prevent them from being displaced or washed ashore by wake forces from barge traffic. Wake forces along shorelines that would be of sufficient magnitude to temporarily affect the success of the rainbow smelt subsistence fishery, which extends for less than a week between Bethel and Upper Kalskag, are not anticipated.

Between July and September 2014, studies were conducted along the mainstem Kuskokwim River and select tributaries to assess the distribution and use of shallow, nearshore habitats by rearing juvenile salmon and other resident fish species. The study was initiated after the spring seaward migration of juvenile salmon to assess the presence and potential vulnerability of fishes to wave forces from barge traffic during summer periods (Owl Ridge 2014b). While high densities of Chinook and coho salmon (and to a lesser extent sockeye and pink salmon) were collected in the Holokuk and Aniak rivers (two of the main tributaries of the Kuskokwim River), few juvenile salmon were collected along the shoreline in the Kuskokwim River mainstem near the mouth of the Holokuk River, near Upper Kalskag, or at Birch Tree Crossing. Instead, nearly 13,000 longnose sucker, about 600 each of arctic grayling and slimy sculpin, and

about 50 each of broad whitefish and round whitefish were collected. Of the fish collected in the mainstem, catch per unit effort was higher from deeper-water habitats (sampled by a 20-m-long seine) compared to shallower areas closer to shore (sampled by a 9-m-long seine). This suggests that from July to early September, following the seaward migration period of salmon, juvenile salmon may rely more on rearing habitats in tributaries where they would not be subjected to potential wakes from barge traffic along the margins of the mainstem Kuskokwim River.

Regarding the potential displacement of spawning adult salmon in the main channel of the Kuskokwim River by barge traffic, such impacts are expected to be minor since most spawning occurs in tributaries outside the main channel. An exception to this involves chum salmon that have been reported to spawn along freshwater tributary plumes near shore on the south side of the river near the seawall in Aniak (Cannon 2013). Based on the run timing shown in Table 3.13-10, the June through early September barge season would overlap the peak upriver spawning runs that extend from mid-June through August for the five species of salmon in the Kuskokwim River. The intensity of potential impacts from barge traffic on migrating adult salmon are expected to be low since adult salmon have sufficient swimming and sensory ability that would generally allow them to sense and avoid approaching tug propeller flow fields as vessel traffic is encountered. High levels of turbidity, which are customary in the Kuskokwim River, would tend to reduce visibility and, in theory, could compromise fish avoidance of tug propellers or their flow fields.

In summary, displacement and/or stranding of small young-of-year and possibly juvenile anadromous fishes may occur from ice breakup to late June during their outmigration, particularly in confined channel segments. Potential risks have been identified where shallow gradient shorelines are exposed to wave forces from downriver-bound barge traffic traveling in narrow channel segments at speeds of 14 fps (over 8 knots or 9 mph) and where wakes of about 9 inches in height could extend to shore. Potential risks to seaward bound salmon migrations would be greatest each year from ice breakup to late June over the life of the project. Areas of potential impact that would occur at a low to medium level of intensity would be localized, occur over the long-term duration of project construction and operation, and primarily involve shorelines with confined channel segments upriver of Aniak. The context of such impacts would be important since the mainstem and its tributaries are regulated as EFH and are important to the Kuskokwim subsistence community. As a result, potential impacts of fish displacement and/or stranding from downriver barge traffic traveling at speeds over 8 knots (about 9 mph) could range from negligible to moderate depending on the character of confined channel segments with shallow-gradient shorelines; the location, timing, and density of schools of small, young-of-year outmigrant salmon encountered by the barge traffic; and the frequency of barge-generated wakes of about 9 inches in height that reach the shore zone in these areas.

Aquatic Invasive Species Introduction Potential

An increase in barge and vessel activity may result in an increase in introduction and spread of invasive aquatic species in the transportation facilities. No invasive aquatic species of any taxa are known from the Project Area, but several species have been identified as high risk threats due to current known distribution in similar habitat in Alaska or on the Pacific coast of North America. Table 3.13-29 lists all potential invasive aquatic taxa (freshwater plants, marine plants, and marine animals).

Ballast water and hull fouling (biofouling) are two major vectors for aquatic invasive species, particularly marine invasive species. Biofouling is considered one of the strongest vectors of invasion transport in marine environments. In Alaska, the EPA Vessel General Permit (VGP) required for barges outlines BMPs for hull fouling prevention and management, but has no regulatory authority. USCG, under the Department of Homeland Security, provides information about voluntary anti-fouling practices.

EPA and USCG have regulatory authority over ballast discharge in Alaska. The EPA VGP outlines permissions for discharge actions. USCG regulations apply to ballast water itself. The AK DEC is the state agency with jurisdictional authority over discharge from vessels, through statute AS 46.03.750. Ballast water discharge is prohibited within the State of Alaska. Donlin Gold's ISMP for the Project would detail requirements for hull fouling practices and ballast water management for all vessel traffic in all Project phases.

All vessel types tend to have niche areas that act as "hotspots" for organism accumulation. Plant parts can also be easily transported in propellers, exterior engine parts, or on board the vessel. Barges move at slow speeds (<11 knots) and have variable duration in ports (generally >24 hours, from several days to several weeks), inviting potential invasion. Barges tend to have hotspots for invasion in ladder holes and dock block areas. Barges visiting the Port of Bethel would come via coastwise traffic, so species of concern are those identified for the western US Pacific coast. Barges transporting materials to and from Angyaruk (Jungjuk) dock site would generally not be the same barges that travel outside the US EEZ to outside ports. If barges do transition from open ocean to the Kuskokwim River, the risk of marine invasions is reduced as most marine invasive species would not survive in freshwater.

Introduction prevention and control is discussed in more detail in Section 3.10, Vegetation, including details of terrestrial invasive plant species and associated BMPs, invasive species transport vectors, and Donlin Gold's Invasive Species Management Plan (ISMP).

BMPs specific to aquatic invasive species in the transportation facilities during all Project activities include:

- Following guidelines in: Preventing Accidental Introductions of Freshwater Invasive Species, USDA Forest Service
(www.fs.fed.us/invasivespecies/documents/Aquatic_is_prevention.pdf);
- Following guidelines in: Decontamination of Crane Bags, NOAA Fisheries Service
(www.habitat.noaa.gov/pdf/best_management_practices/Decontamination%20of%20Crane%20Bags.pdf);
- Following guidelines in: Cleaning Watercraft and Equipment, NOAA Fisheries Service
(www.habitat.noaa.gov/pdf/best_management_practices/Cleaning%20of%20Watercraft%20and%20Equipment.pdf);
- Following guidelines in: Decontamination of Invasive Bivalve Species, NOAA Fisheries Service
(www.habitat.noaa.gov/pdf/best_management_practices/Preventing%20Spread%20of%20Invasive%20Bivalve%20Species.pdf);

- Following guidelines in: Decontamination of shells used for Habitat Restoration, NOAA Fisheries Service
(www.habitat.noaa.gov/pdf/best_management_practices/Decontamination%20of%20Shells.pdf);
- Following guidelines in: US Coast Guard guidance on hull fouling maintenance, through the International Maritime Organization (IMO)'s guidelines on controlling and managing biofouling
([www.imo.org/blast/blastDataHelper.asp?data_id=30766&filename=207\(62\).pdf](http://www.imo.org/blast/blastDataHelper.asp?data_id=30766&filename=207(62).pdf)); and
- Check, clean, and dry all clothing, boots, and equipment (boats, trailers, nets, etc.) prior to visiting a site.

Table 3.13-29: Potential Aquatic Invasive Species

Category	Common Name	Scientific Name	Vector	Habitat and Ecophysiology
Crab	European green crab	<i>Carcinus maenas</i>	larval transport in ballast water	Estuarine environments. Voracious feeder on juvenile native crab and shellfish.
Algae	caulerpa, killer seaweed	<i>Caulerpa taxifolia</i>	aquarium dumps; larval transport in ballast water	Cold temperate marine environments. Common aquarium species. Grows voraciously on all surfaces in marine environments. Outcompetes all other species.
Algae	Asian kelp, wakame	<i>Undaria pinnatifida</i>	larval transport in ballast water; hull fouling	Cold temperate marine environments. Cultivated food species. Outcompetes other species and smothers marine surfaces.
Amphipod	no common name	<i>Monocorophium ascherusicum</i>	ballast water	Free marine species. Ecophysiology largely unknown.
Amphipod	no common name	<i>Elasmopus rapax</i>	ballast water	Free marine species, depth range from about 0 to 100 meters. Often among algae in shallow sub-tidal habitats.
Ascidian - colonial tunicate	sea squirt, marine vomit, d-vex	<i>Didemnum vexillum</i>	floating rafts, infested material, infested aquaculture stock	Forms colonies. Completely smothers seafloor, grows over all substrate and other organisms, destroys marine habitat.
Ascidian - colonial tunicate	star ascidian, golden star tunicate	<i>Botryllus schlosseri</i>	floating rafts, infested material, infested aquaculture stock, hull fouling	Forms colonies in flat sheets that often appear lobate. Adheres to docks, boat hulls, buoys, ropes, pilings, rocks, mussels, solitary sea squirts, seaweeds, and eelgrass. Filter feeder by water pump.
Ascidian - colonial tunicate	sea squirt	<i>Botrylloides violaceus</i>	floating rafts, infested material, infested aquaculture stock, hull fouling	Forms colonies arranged in columnar systems with a firm, clear matrix. Adheres to docks, boats hulls, buoys, ropes, pilings, rocks, eelgrass blades, and seaweeds. Overgrows mussels, barnacles, bryozoans, and solitary sea squirts. Filter feeder by water pump.

Table 3.13-29: Potential Aquatic Invasive Species

Category	Common Name	Scientific Name	Vector	Habitat and Ecophysiology
Ascidian - solitary tunicate	vase tunicate, sea squirt	<i>Ciona intestinalis</i>	hull fouling, infested materials, ballast water	Solitary form with vase-like shape. Grows on pilings, aquaculture gear, floats, boat hulls. Lower intertidal to tidal zone
Ascidian - solitary tunicate	transparent ciona, Pacific transparent sea squirt	<i>Ciona savignyi</i>	hull fouling, infested materials, ballast water	Solitary form with pillar-like shape up to 15 cm long. Forms dense patches on docks, pilings, marinas, harbors, and aquaculture structures.
Ascidian - solitary tunicate	club tunicate, stalked tunicate	<i>Styela clava</i>	hull fouling, infested materials, ballast water	Solitary form with club-like shape up to 20 cm long. Often covered with other organisms. Grows on rocks, floats, pilings, oyster and mussel shells, and seaweeds. Filter feeder by siphon.
Bryozoan	no common name	<i>Waterispora subtorquata</i>	hull fouling	Colonial growth on rocks, shells, docks, vessel hulls, pilings, debris, keel holdfast, other bryozoans.
Bryozoan	spiral tufted bryozoa	<i>Bugula neritina</i>	hull fouling	Colonial growth in upright, bushy, branching tufts up to 15 cm, often mistaken for seaweed. Filter feeding by tentacles. Grows in intertidal to shallow subtidal zones on dock sides, buoys, pilings, rocks, shells, seaweeds, sea grasses, sea squirts, and other bryozoans.
Snail	Japanese drill snail, hornmouth snail	<i>Ceratosstoma inornatum</i>	larval transport in ballast water	Estuarine and marine habitats in cool waters. Feeds voraciously on oysters.
Snail	Eastern oyster drill, Atlantic oyster drill	<i>Urosalpinx cinerea</i>	ballast water	Intertidal and shallow subtidal waters to a maximum depth of 15m. Common on rocks and oyster reefs. Feeds on oysters, barnacles, mussels, and snails.
Snail	Eastern mud snail	<i>Nassarius obsoletus (Ilyanassa obsoleta)</i>	larval transport in ballast water	Mud flats in intertidal and shallow subtidal zones, in sounds and inlets. Forms large herds. Feeds on diatoms, algal detritus, worms, dead fish, crabs, and other animal remains.
Copepod	no common name	<i>Oithona davisae</i>	ballast water	Free marine species in temperate coastal waters. Ecophysiology largely unknown.

Table 3.13-29: Potential Aquatic Invasive Species

Category	Common Name	Scientific Name	Vector	Habitat and Ecophysiology
Aquatic Plant, Marine	cordgrasses	<i>Spartina spp.</i> (<i>S. alterniflora</i> , <i>S. anglica</i> , <i>S. alterniflora x foliosa</i> , <i>S. densiflora</i> , <i>S. densiflora x foliosa</i> , <i>S. patens</i>)	floating plant parts	Mudflats. Fills and uplifts habitats. Alters fish nursery habitat structure and shoreline structure.
Aquatic Plant, Freshwater	elodea, waterweed	<i>Elodea spp.</i> (<i>E. nuttallii</i> , <i>E. canadensis</i> , hybrids)	plant parts, transport by float plane or boat	Still or moving freshwater lakes, ponds, and streams. Tolerates freezing and very cold temperatures. Can reproduce from tiny fragments. Spreads rapidly. Outcompetes native aquatic vegetation and chokes waterways.

Source: Davis 2015; Shaw 2015.

Prop Wash, Bed Scour, and Fish Injury/Mortality

Prop Wash and Bed Scour

Propellers of tugs and other vessels produce jets of water and hydraulic forces (prop wash) that diffuse through the water column which, if reaching the bottom of a river can scour sediments along the riverbed and cause displacement and mortality of fish or other aquatic life (Corps 2006c; Maynard 2000; Verhey 1983; Anchor OEA, LLC 2009; CH2MHill 2011e; Mazumber et al. 1993; Killgore et al. 2005; Holland 1986; Gutreuter et al. 2003; Corps 2005; Hayes et al. 2012). The bed and shore zone of a river can be subjected to scouring from excessive water velocities extending from the flow field of a propeller jet, particularly if the channel is shallow or the bank is close to a vessel's line of travel (see Section 3.5, Surface Water Hydrology, for additional analysis related to propeller scour).

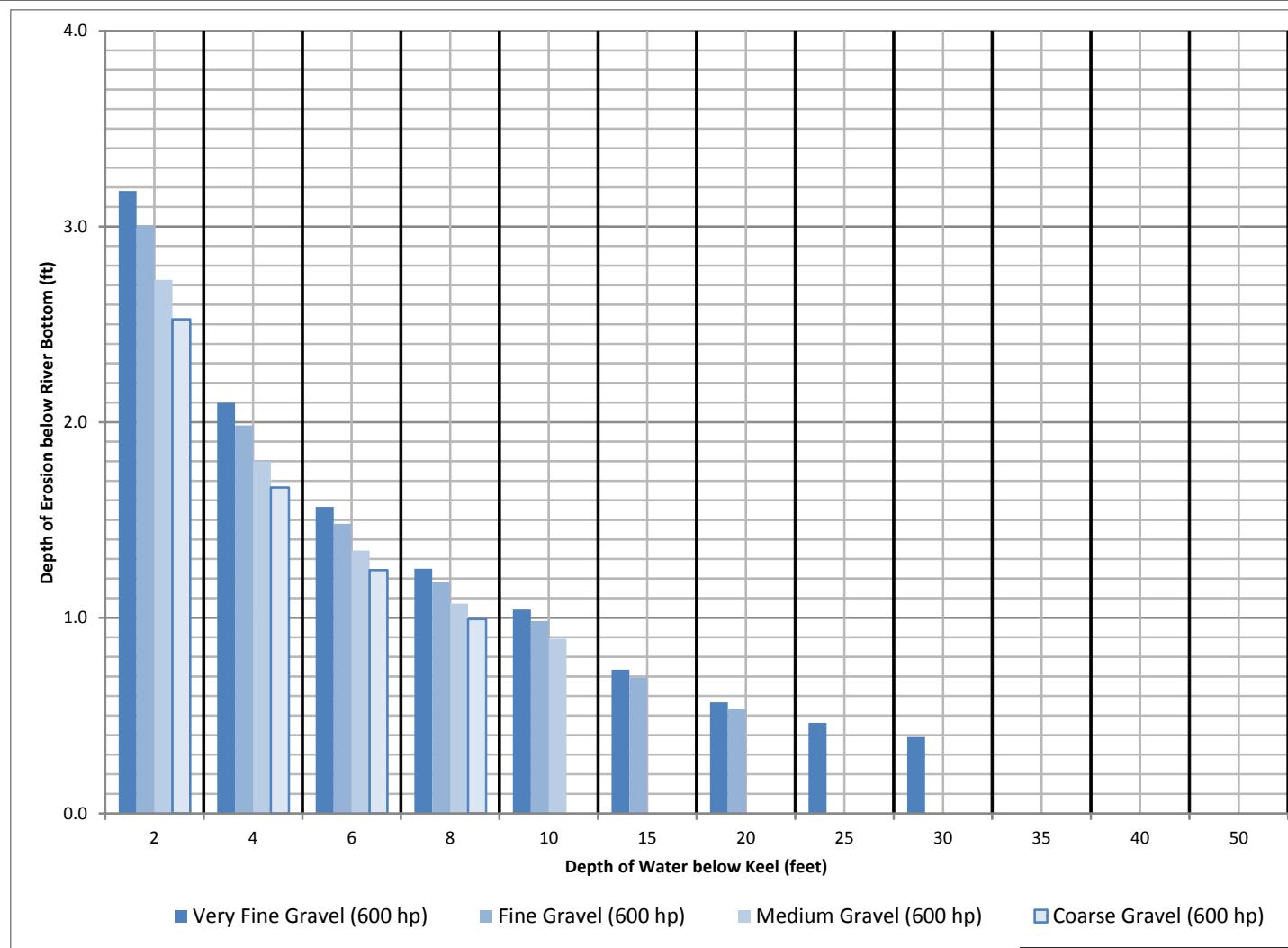
Mazumber et al. (1993) indicate that large changes in velocities and energy scour can occur in a zone within 10 percent of the channel width from shore as a result of the water turbulence from a vessel in transit. The magnitude of shoreline erosion, bank failure, and bed scour that may be caused by prop wash from tugs, or other vessels, is controlled by several factors including propeller size and number, engine horsepower, propeller depth and orientation in the water, vessel speed, under keel water depth, distance to shore, and character of affected soils and bed substrates (CH2MHill 2011e). Such turbulence can increase suspended sediment concentrations and turbidity, alter water quality, and affect ecological and physiological processes of biota at both the population and individual level. In riverine systems where naturally occurring turbidity and sediment do not exist at high levels, prop wash also can affect the distribution and productivity of benthos, aquatic plants, and fish and can impact the transport and dispersal of eggs and larval life stages of fish (Corps 2000a).

Liou and Herbich (1976, 1977) concluded that the ratio of water depth to a vessel's draft is the predominant factor affecting the movement of sediments by prop wash. The authors

determined that little movement of sediment occurs when the ratio of water depth to vessel draft was greater than two. This implies that for a vessel with a 3-foot draft, a 6-foot water depth should result in minimal disturbance to the riverbed, depending on the substrate character. For the proposed project, a 3-foot minimum operating draft was assumed for tugs and upriver bound cargo and fuel barges during low-water/shallow passage conditions. This included allowance for vessel squat or the additional draft caused by a vessel in motion. For downriver bound traffic, the draft for cargo and fuel barges was assumed to be 2.3 feet and 1.4 feet, respectively, although heavier loads may result in deeper drafts during periods of higher flows depending on river stage and water depth. When the river stage (and depth) increases during periods of high flow, the maximum operating draft of cargo and fuel barges was assumed to increase to 7.5 feet (AMEC 2014). To minimize potential impacts of bed scour, barge traffic would be tracked using GPS and real-time river stage and depth monitoring systems to ensure vessel passages are conducted through the deeper portions of the channel, especially in confined and shallow segments of the river.

To evaluate the intensity and extent of bed scour that could result from the proposed project, an empirical model developed by Maynard (2000) was used to predict water velocities and related sediment scour along the bottom of a theoretical river channel based on variable under keel water depths and engine power ratings of 150 to 600 horsepower (AECOM 2015d). Calculations indicated that propeller forces from a tug with a 600 hp engine (most conservative case) moving slowly through shallow water with under keel water depths of 2 and 6 feet would generate bottom velocities of 11.9 and 3.5 fps, respectively. Velocities of this magnitude would be sufficient to scour large cobbles and coarse gravel greater in size than the materials measured at sampling stations in confined sections of the Kuskokwim River. Based on under keel water depths of 10 feet (13 feet total depth assuming a 3-foot vessel draft) or deeper, the model predicted that bottom velocities along the propeller flow path would be negligible and the depth of scour of medium to coarse gravel would be eliminated or substantially reduced depending on the horsepower rating of the tug (Figure 3.13-9, Figure 3.13-10, Figure 3.13-11, and Figure 3.13-12).

Figure 3.13-13 presents a schematic view of a theoretical tug (propelled by a 600 hp engine) with a four-barge tow traveling in water with an under keel clearance of 3 feet. The area behind the tug that would correspond to the propeller flow field along the riverbed is shown by colors representing a gradient of velocities. As shown in the figure, velocities would range from up to 3.4 fps (yellow) for about the first 100 feet from the stern of the tug to less than 1 fps at about 250 feet from the stern. The horizontal extent of the flow field would closely approximate the 88-foot width of the two-by-four-barge tow. Wider and possibly deeper zones of scour would be expected where tugs are stationary or slowly maneuvering as when barges are being brought to berthing stations at the port site or when staging at confined channels to modify barge configurations.



Notes:

1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:

Diameter of propeller - 40 inches
 Distance from keel to propeller centerline - 22 inches
 Minimum draft - 3 feet
 Ducted propeller



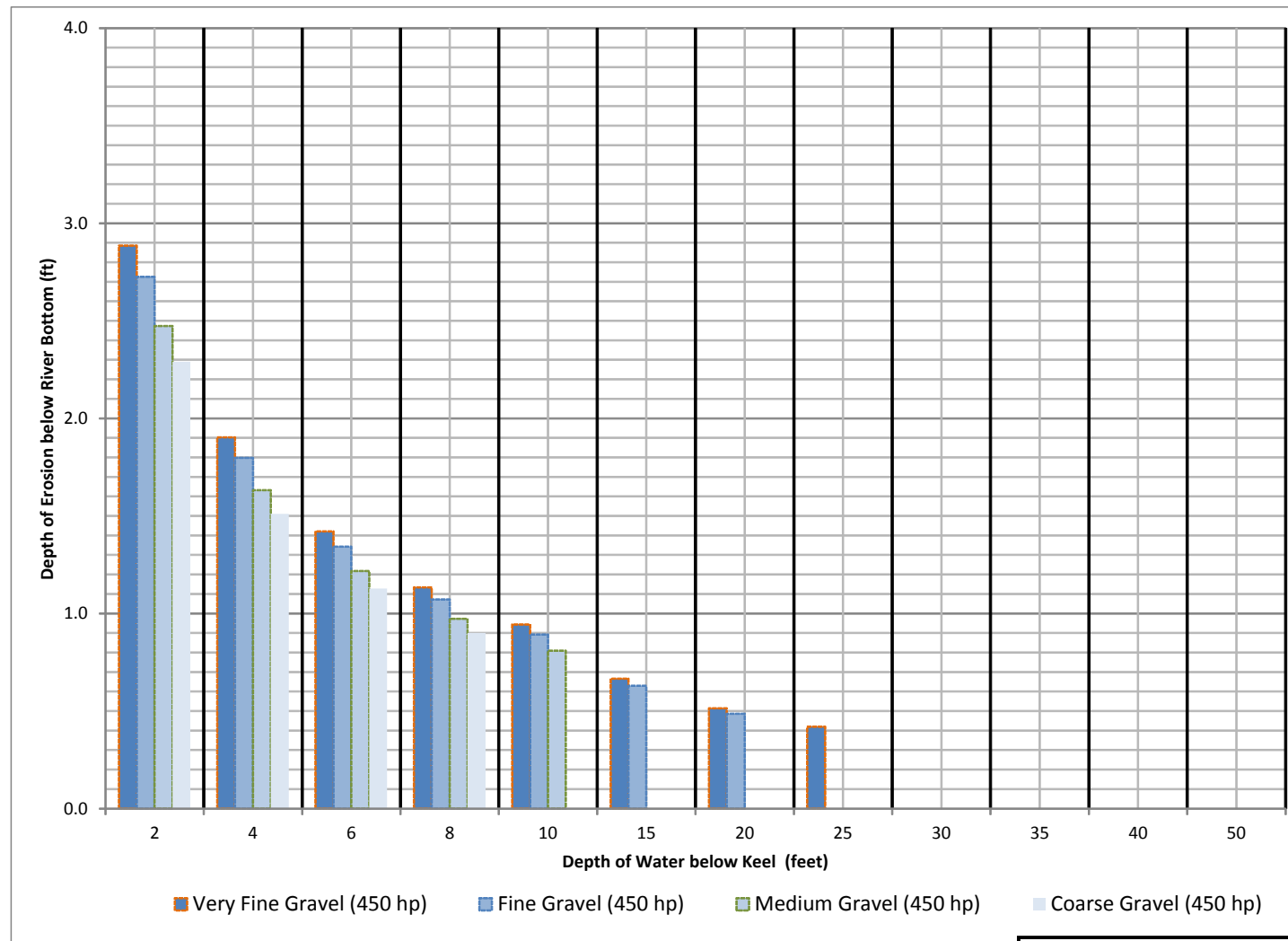
DONLIN GOLD
PROJECT EIS



**ESTIMATED SCOUR DEPTH BY
 GRAIN SIZE AND WATER DEPTH
 FOR A 600 HP TUG**

NOVEMBER 2015

FIGURE 3.13-9



Notes:

1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:

Diameter of propeller - 40 inches
 Distance from keel to propeller centerline - 22 inches
 Minimum draft - 3 feet
 Ducted propeller



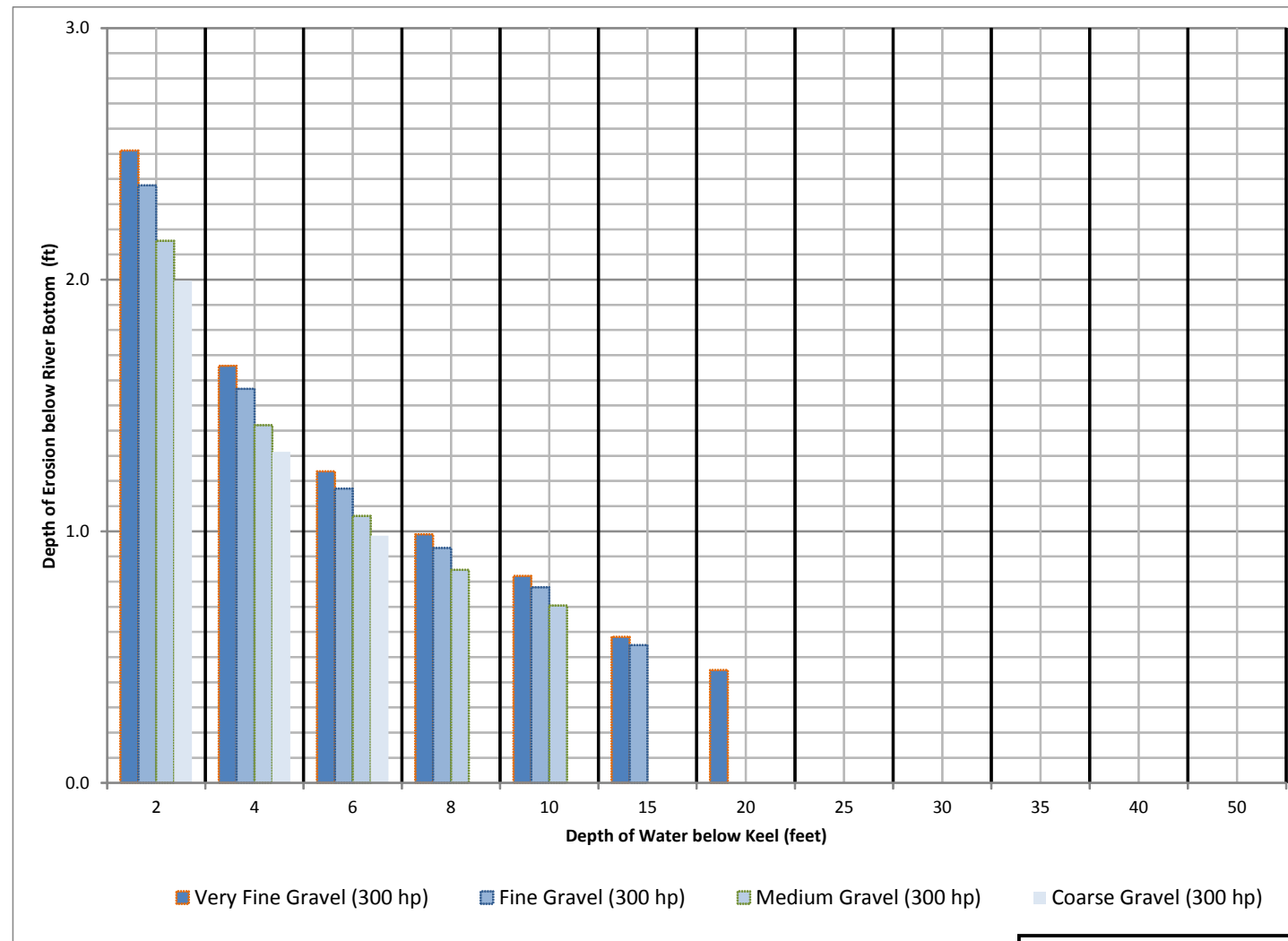
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**ESTIMATED SCOUR DEPTH BY
 GRAIN SIZE AND WATER DEPTH
 FOR A 450 HP TUG**

NOVEMBER 2015

FIGURE 3.13-10



Notes:

- Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
- A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:

Diameter of propeller - 40 inches
 Distance from keel to propeller centerline - 22 inches
 Minimum draft - 3 feet
 Ducted propeller



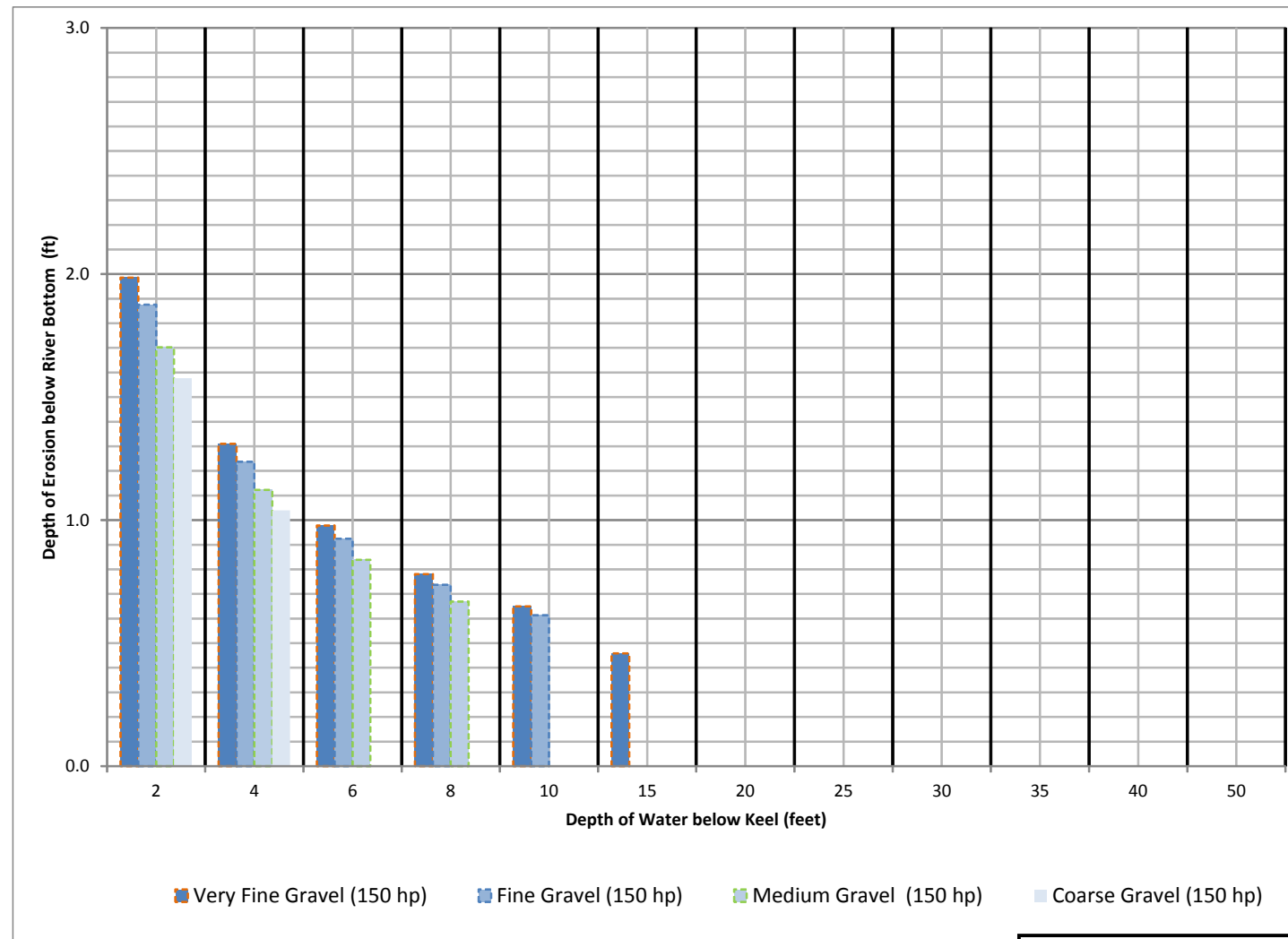
**DONLIN GOLD
 PROJECT EIS**



**ESTIMATED SCOUR DEPTH BY
 GRAIN SIZE AND WATER DEPTH
 FOR A 300 HP TUG**

NOVEMBER 2015

FIGURE 3.13-11



Notes:

1. Results are based on Hong et al. (2012) and represent scour under a stationary tow after 1 minute. This provides a conservative estimate of scour since scour under a moving tow would be less and would be spread over a large distance due to the movement of the tow. For example a tow moving at 5 mph would move about 400 feet in 1 minute.
2. A typical upriver tow with a full barge load would be powered by a 450 hp tug operating at 75% of maximum throttle (Fernandez 2014d).

Assumptions:

Diameter of propeller - 40 inches
 Distance from keel to propeller centerline - 22 inches
 Minimum draft - 3 feet
 Ducted propeller



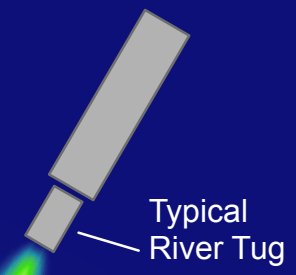
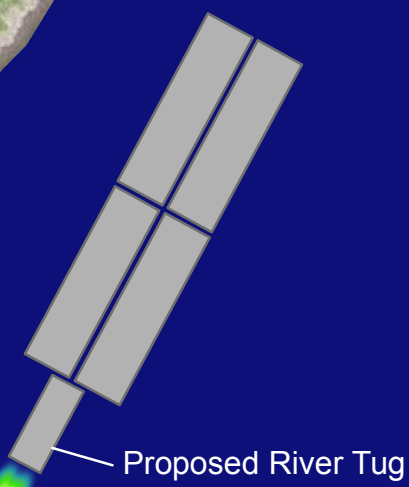
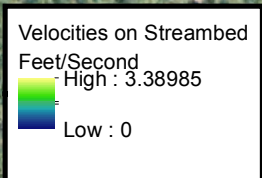
**DONLIN GOLD
PROJECT EIS**



**ESTIMATED SCOUR DEPTH BY
GRAIN SIZE AND WATER DEPTH
FOR A 150 HP TUG**

NOVEMBER 2015

FIGURE 3.13-12



Results for upstream travel in shallow water (3 ft under keel);
at full throttle (600 hp/prop - proposed, 375 hp/prop - existing);
4 props/tug proposed, 2 props/typical.
Source: AECOM 2015d



DONLIN GOLD
PROJECT EIS



ESTIMATED PROPELLER-INDUCED WATER VELOCITY AT STREAMBED

NOVEMBER 2015

FIGURE 3.13-13

As previously mentioned, 2014 rainbow smelt surveys determined that spawning occurred in late May upriver of Upper Kalskag at a mean depth of 8.5 feet along the sides of the mainstem channel. Spawning occurred at a similar time in 2015 but at locations downriver from Lower Kalskag in a narrower river segment at a mean depth of 14.5 feet (Owl Ridge 2014a; 2015a). Depending on water depths and locations where rainbow smelt spawning occurs during construction and operations and maintenance phases of the project, hydraulic forces from propellers of passing tugs could scour substrates and dislodge or displace incubating eggs resulting in injuries or mortalities. Eggs spawned in late May typically incubate for about 21 days before larvae drift downstream to the estuary. The timing for this, however, depends on water temperatures during this period which may vary from year to year. Incubating eggs, therefore, could be at risk of potential displacement, injury, or mortality from barge traffic from about late May to mid-June.

Impacts from prop wash could be reduced if barge traffic between late May to mid-June travels along the deepest portions of the channel in reaches where rainbow smelt spawning has been previously documented. Disturbance to substrates (and incubating eggs) would be minimized if barges travel along depth contours that would allow the tug to maintain a gross under keel clearance greater than 15-20 feet. During the 2015 rainbow smelt spawning survey, spawning occurred as shallow as 8.7 feet along a relatively confined channel segment. In such locations, a medium to high level of injury or mortality to incubating eggs could have resulted from the propeller scour of passing tug traffic, depending on the tug's horsepower rating and engine speed. Because of the narrow width and relatively shallow depth across this particular channel segment, it is unlikely that impacts to incubating rainbow smelt eggs could have been avoided by altering the line of travel of barge traffic. Similar impacts to other resident fish species that could spawn in the mainstem channel also would be at risk.

Based on this analysis, prop wash from a tug in passage is expected to cause a medium to high intensity of scouring to gravel-size riverbed substrates at localized areas along the navigation route, particularly in waters with an under keel depth shallower than approximately 8 to 10 feet. Such impacts would extend over a long-term duration from construction through operation. Over time, the natural sediment load in the river would tend to re-fill the scoured substrates to an undetermined extent. While the zone of turbulence from tug propellers could extend laterally about as wide as two parallel barges in tow (about 88 feet), the width and depth of scour along the riverbed could vary, especially where tugs are stationary, maneuvering, or traveling through shallow waters. A medium to high magnitude of scouring could displace, injure, or cause mortalities to eggs of rainbow smelt, an important anadromous forage fish species known to spawn in gravel-cobble substrates along limited segments of the Kuskokwim River near Kalskag.

Bed scour from existing barge traffic, flooding, and ice-out conditions also contribute to sediment re-suspension and displacement of fish eggs and larvae and other aquatic biota. The additive effects of bed scouring from proposed barge traffic would be long-term and local in extent involving shallower sections of the Kuskokwim River along the navigation channel. Since natural flooding and existing small boat and barge traffic already contribute to riverbed scouring within the navigation channel in certain locations, displacement of aquatic habitat and biota in areas previously disturbed may be negligible. As a result, impacts from prop wash scour on anadromous or resident fish and aquatic life that rely on mainstem channel areas for spawning that have not been previously subjected to natural flooding or existing small boat and barge traffic could be moderate to major depending on how and where tugs are operated, water

depth, channel geometry, substrate character, and life stages of fish and aquatic species that encounter such hydraulic forces.

To minimize or avoid impacts of prop wash forces on early life stages of fish and in recognition of ever-changing river conditions, a series of operational measures would be implemented that include:

- Maintaining detailed logs of river conditions, including measurements of depths and current speeds and directions at critical reaches, by tug captains during each trip with information made immediately available to other fleet captains;
- Restricting passages through shallow and narrow river segments with sharp bends to one-way traffic using radio check control when approaching and after completing such passages; and
- Use of electronic charts, GPS radar overlay, barge speed and location monitoring, continuous crew training, river navigation aids along the travel route, and an ongoing analysis and mapping of areas with potential operational and ecological risks.

Future studies of barge passages during the early construction phase are proposed that would provide an improved basis for evaluating potential areas of risk relative to impacts from riverbed scour, bank erosion, and nearshore velocities at various depths, locations, and channel configurations. Such studies also could determine the feasibility and effectiveness related to adjusting the timing, speed, or line of travel of barge traffic in certain areas to avoid or minimize impacts on fish and aquatic habitats including areas uniquely identified as important to rainbow smelt spawning.

Fish Injury and Mortality

While specific impacts of propeller-induced injury or mortality to anadromous or resident fishes in the Kuskokwim River from barge traffic are uncertain, such impacts have been evaluated elsewhere. According to Gutreuter et al. (2003), commercial vessels operating in confined channels of large rivers may cause injuries or mortalities to fish eggs, larvae, or juvenile life stages caused by exposure to hydraulic shear forces, propeller strikes, or water pressure changes in a propeller's flow field.

Killgore et al. (2005) reported that instantaneous mortality of fish collected in a specially designed net after being entrained through twin-screw towboat propellers was minimal in studies conducted on the Mississippi and lower Illinois rivers. Sampling, which consisted of 139, 10-minute trawls, was dominated (96 percent) by the herring family *Clupeidae* and gizzard shad (*Dorosoma cepedianum*). It should be noted that fish of the size and age sampled in the study have a greater swimming ability than larval, young-of-year, or larger-size juvenile salmon. When instantaneous mortality of fish entrained through towboat propellers was observed, it was found that only gizzard shad were susceptible to entrainment in any measurable number. All but one of the injured or killed fish also had visible net marks on their bodies which may have contributed to injuries. The mean entrainment mortality rate for upriver-bound tows was equivalent to 0.01 to 1.0 fish/km of towboat travel which also included net-induced injuries. Although not measured, additional delayed mortalities also may have occurred. Since the entrainment mortality was slightly higher in the Illinois River where the channel was narrower, the author suggests that pelagic fishes inhabiting the mid to upper water column of small or narrow navigation channels may be more susceptible to propeller

entrainment where populations are confined and concentrated. Similar studies by Gutreuter et al. (2003) estimated the mean entrainment mortality of gizzard shad at 2.52 fish/km (80 percent confidence interval of 1.00 to 6.09 fish/km). Fish injury or mortality from tug and barge traffic on the Kuskokwim River may be somewhat greater if shallow-draft tug and barge combinations would have propellers that are closer to the surface where portions of the seaward migrating salmon often travel in mid-channel, high-velocity waters.

A study by Holland (1986) assessed short-term impacts of deep-draft commercial barge traffic on fish eggs, larvae, young-of-year fishes, and small adults in the upper Mississippi River based on net sampling prior to and 45 and 90 minutes after vessel passage. Results indicated that downstream (loaded) vessels caused an immediate reduction in mean catch that continued through the 90-minute sampling period while the mean catch increased in surface waters immediately after upstream (unloaded) passage. Gross damage to larval fish was rarely observed and no consistent pattern of injury from barge passages was apparent. Results of the study indicated that impacts of barge passages on the distribution of drifting eggs and larvae is primarily related to the physical effects of the vessel on the water column relative to wave forces and drawdown that alter water levels along the margins of the channel.

Evaluating impacts of barge traffic relative to potential fish injuries or mortalities on the Kuskokwim River requires consideration of the timing, distribution, and density of anadromous and resident fishes, particularly during the seaward migration of young-of-year salmon and larval life stages of resident fish, within confined segments of the main channel. To evaluate this, surveys of fish populations were conducted in nearshore waters and the mid-channel of the Kuskokwim River during May and June of 2015 near Birch Tree Crossing and above Upper Kalskag. The abundance of young-of-year chum and coho salmon smolts captured during the survey were highest in mid-May through June 1 and decreased substantially by June 19 to 22. Over 21,000 young-of-year chum, about 400 coho smolts, and lesser amounts of pink, sockeye, and Chinook salmon were collected during the survey (Owl Ridge 2015b). While other information on the timing and distribution of outmigrant salmon in the mainstem Kuskokwim River is limited, investigations by Burril et al. (2009) determined that juvenile chum and other salmon species from the Kwethluk River (a tributary of the lower Kuskokwim River) migrate to sea from early May to mid-June. During the study, seaward migrations for all salmon species tended to be greatest when water levels, which are generally clearer in this tributary than in the mainstem Kuskokwim River, were rising and during the hours of low light (i.e., 02:00 to 08:00). Based on 2003 and 2004 studies in Kuskokwim Bay, the peak abundance of downstream migrating pink, coho, and sockeye salmon was greatest in late May, while chum and Chinook salmon had the greatest peak abundance in mid to late June (Hillgruber and Zimmerman 2009). Similar findings regarding the timing of out-migrating salmon in the Yukon Delta has been observed in other studies (Martin et al. 1986).

The distribution and use of shoreline, mid-channel, and other river habitats by juvenile salmon during their downstream migration has been investigated by researchers who have described patterns that varied by species, river systems, and time of day. Radio tracking studies suggest that downstream juvenile salmon migrations are not continuous but interspersed with periods of holding. In addition, downstream migrating fish have been reported as typically swimming in the fastest water available (Quinn 2005). Studies by Neave (1955) noted that populations of pink and chum salmon in British Columbia have been observed migrating downstream exclusively at night. Individuals not reaching the estuary during their first night of migration moved temporarily back into streambed gravels during the day and resumed their migrations

the next night. Coho salmon in the Chehalis River in Washington were estimated to spend 40 percent of the time swimming downstream and 60 percent holding (Moser et al. 1991). While much of their downstream migration took place during daylight hours, they also temporarily held in back eddies and off-channel habitats containing woody debris and cover consistent with the findings of McMahon and Holtby (1992). Others also have reported that seaward migrating salmon have been observed, at times, to utilize shallow waters of less than 3 feet in depth and within 33 feet of shore (Owl Ridge 2014b). Such shallow shoreline zones also have been reported to function as important nursery areas for non-migrating, rearing fishes (Winkler et al. 1997; Keckeis et al. 1997).

Besides young salmon, larval and juvenile life stages of other fish species also could be subject to injury from barge traffic to an unknown extent. Between April and early September, for example, juvenile life stages of rainbow smelt, least cisco, broad whitefish, humpback whitefish, inconnu (sheefish), and Arctic grayling (among others) migrate in the Kuskokwim River often during spring or early summer floods. Arctic and Pacific lamprey migrate to the estuary in August and September.

In the Kuskokwim, barge traffic navigating deeper and wider sections of the river typically would not pass close to shore, depending on the channel's geometry. Under such conditions, rearing or migrating salmon and other anadromous and resident fishes in shore zone areas would tend to experience low levels of risk relative to injury or mortality from tug propellers, vessel wakes, drawdown and surge, prop wash, and other associated hydraulic forces. In more confined segments of the channel, however, a relatively higher level of injury or mortality could occur to eggs, larvae, and possibly young-of-year resident or anadromous fishes that encounter shear forces from tug propellers, especially where these populations are concentrated.

As described earlier, the greatest concentrations of seaward migrating salmon in the Kuskokwim River (traveling from tributaries to Kuskokwim Bay) are likely to occur between early May and late June, and possibly during hours of low light and rising water levels (Burril et al. 2009; Hillgruber and Zimmerman 2009). Based on studies described earlier, fry-size and older juvenile salmon tend to occupy high-velocity portions of the river channel as they actively swim toward the estuary during their seaward migrations. Some species, such as chum and pink salmon, periodically hold in slower, shallow waters along shorelines, back eddies, and side channels during their seaward migration. Similar to seaward migrating salmon, early life stages of other resident and anadromous fishes, such as rainbow smelt, whitefish, sheefish, lamprey, and least cisco, that actively migrate or drift downriver would be subject to potential injury or mortality from tug propeller forces. The extent and intensity of impacts would depend on the timing and locations in the river channel where concentrations of these fishes would intersect with vessel traffic.

The timing and locations when/where fish concentrations could be greatest and susceptible to potential injury or mortality at a low to high level of intensity would generally depend on the life stages of fish that would be at risk. Fish eggs, larvae, and small young-of-year juvenile life stages moving downstream would be at higher risk compared to upstream migrating adult fish with stronger swimming ability. Adult and larger juvenile fish that tend to follow shallower shoreline areas with lower velocity would be less susceptible to shear forces from propellers and propwash in the middle of the river channel. Where impacts could occur, they would be long-term in duration over the life of the project and local with greatest risk occurring in confined channel segments between Kuskokwim Bay and the Angyaruaq (Jungjuk) Port site

(and to a lesser extent, upriver to the pipeline crossing of the Kuskokwim). Such impacts would have an important context since they would affect EFH and associated species protected under the Magnuson-Stevens Act. Therefore, anticipated fish injuries or mortalities from tug and barge traffic along the navigation channel would range from negligible to moderate depending on the seasonal timing of fish migrations, life stages, time of day, and the concentration of fish encountered by barge traffic relative to confined and shallow channel segments. Although fish species potentially at risk would be common to the Kuskokwim River system, the mainstem and its tributaries have an important context in that they are regulated as EFH since these waters provide habitat that supports key life stages of salmon which also are important to the Kuskokwim subsistence community.

Mine Access Road and Port Site

Under Alternative 2, a new, 30-mile, two-lane, 30-foot-wide access road would be constructed to transport cargo and fuel from the barge landing at the Angyaruaq (Jungjuk) Port site to the mine. The all-season, gravel road would be used exclusively for mine-related traffic and would remain in service in perpetuity to support post-closure compliance monitoring at the mine. Performance bonds would be established so the road and all bridges and culverts are regularly monitored and properly maintained and that all maintenance equipment would be available onsite to do so. Water trucks and BMPs for managing runoff would be used to control dust and the release of fine sediments to local streams. The road would cross approximately 51 streams or drainages using 45 culverts varying in size from 24 to 72 inches and 6 bridges. In addition, rock and gravel for construction of the road would be removed from about 13 material sites along the road corridor with a primary site that would be located between the confluence of the north and south forks of Getmuna Creek. Truck traffic, carrying fuel and cargo, would arrive at the mine site or Angyaruaq (Jungjuk) Port site about every half hour, on average, during the approximately 110-day shipping season. Daily traffic would typically consist of 20 trucks making 54 trips (half each for fuel and cargo) with a one-way trip requiring about 1.6 hours.

Historically, road construction and maintenance practices can result in potential risks to nearby streams and drainages from increased surface erosion and deposition of fine sediments; alteration of water temperature; delays or barriers to fish migration at culverts; changes in streamflow and hydrologic processes; and introduction of invasive plant species (NMFS 2011a). Surface erosion can result from clearing, grading, and excavation activities and from poorly surfaced or maintained roads with steep grades, high levels of traffic, and insufficient stormwater management facilities. Accumulations of fine sediments in streams have been associated with decreased fry emergence, reductions in winter carrying capacity and benthic production, and changes in species composition in benthic communities (NMFS 2011a; Bisson and Bilby 1982; Bilby et al. 1989).

Downgradient from the proposed mine access road corridor and at material borrow sites near streams, potential construction impacts related to erosion and sedimentation and loss of shade from removal of trees and riparian plant communities could adversely affect fish communities and aquatic habitat particularly at bridges or culvert crossings. Such impacts would be managed and monitored by implementing specific construction and maintenance BMPs that will be finalized during the design and agency review processes including specifications required for the Title 16 Fish Habitat Permit. A range of BMPs, including silt fences, bale check dams, sediment retention basins, cross bars and ditches, runoff interception and diversions, gabions and sediment traps, mulching of disturbed surfaces and stockpiles, and other measures,

would be installed and monitored along the road corridor and at all bridge and culvert crossings to ensure they effectively reduce the intensity of runoff, erosion, and sediment loads and minimize potential impacts to fish, other aquatic life, and their habitats.

Periodic, temporary barriers to fish passage could occur over all phases of the project from construction through post-closure monitoring. The intensity of impact to fish populations is expected to range from low to medium depending on the nature, location, and magnitude of potential blockage incidents and the timing required to restore fish passable conditions.

Mine access road aquatic invasive species risk is similar to that of the mine site. Jungjuk Port site aquatic invasive species risk would also include marine aquatic invasive risk, and is similar to that of the transportation facilities risk level.

The main tributaries that would be crossed by the mine access road are the north and south forks of upper Getmuna Creek and Crooked Creek. These crossings would involve full-span bridges. Getmuna Creek represents some of the highest salmon and resident fish production in the drainage (Figure 3.13-1). Elsewhere along the roadway corridor, small creeks and drainages would be crossed by culverts. Culvert and bridge construction would be conducted consistent with specifications included in the Title 16 Fish Habitat Permit which would be implemented to protect in-water habitat, minimize impacts during construction, and assure long-term fish passage throughout the post-closure monitoring phase. Inspection and maintenance of culverts, bridges, and roads would be regularly conducted and reported in compliance with permit conditions. Should culvert blockages occur, they could erode stream channels and contribute to sedimentation in waters downstream until water conveyance and fish passage are properly restored.

During construction, rock blasting would periodically be conducted within or near streams along the road corridor, at materials sites, and elsewhere in the mine site area. All blasting would be conducted in compliance with the Title 16 Fish Habitat Permit and the Alaska Blasting Standard for the Proper Protection of Fish (Timothy 2013). This would include implementation of a suite of BMPs and alternative measures to avoid, minimize or mitigate impacts of blasting on all life stages of fish as determined during the final design and permitting processes. BMPs that would be developed during final design typically include:

- identification of spawning beds, rearing areas, and migration corridors in the blast area;
- scheduling of all blasting when fish and embryos are not present in the area;
- estimating number of blasts, maximum charge weight per day, distance between fish habitat and detonation sites;
- predicting maximum overpressures in affected waters and peak particle velocities in spawning gravels;
- use of alternatives to blasting;
- displacing, removing, and blocking fish from the area prior to blasting activities; and
- resloping, restoring, and revegetating disturbed streambanks based on methods presented in Walter et al. (2005).

By implementing blasting BMPs required in the Title 16 Fish Habitat Permit, pressure waves and vibrations that could otherwise jeopardize fish life phases (i.e., adults, juveniles, eggs, or

larvae) would be monitored. This could include the use of hydrophones installed in appropriate locations near the point of detonation during all blasting activities. The instantaneous pressure rise in the water column in fish rearing and migration habitat would be limited to no more than 7.3 psi where and when fish are present. Peak particle velocities in spawning gravels would be limited to no more than 2 inches per second during the early life stage of embryo incubation (Timothy 2013). By incorporating these and other BMPs into the final design, as confirmed in the Title 16 Fish Habitat Permit, the level of intensity of blasting impacts on aquatic habitat and fish populations would be low and would occur over the relatively short-term duration of construction along the mine access road and at the materials sites. Potential impacts would be localized and limited to the immediate vicinity of detonations. The context of such impacts would be important as they could affect EFH and related fish populations regulated by the Magnuson-Stevens Act. Therefore, potential impacts related to rock blasting along the mine access road and material borrow sites would be minor.

Based on the design standards and BMPs that would be implemented in compliance with the Title 16 Fish Habitat Permit, the number of stream crossings proposed, and the extent of the mine access road corridor, the intensity of anticipated impacts on fish and aquatic resources and their associated habitat would be low to medium. The context of impacts would be important since some of the streams to be crossed by bridges and culverts are regulated as EFH. Anticipated impacts would be local in extent over a long-term duration extending from construction through post-closure monitoring. Therefore, anticipated overall impacts associated with the mine access road would be minor. Impacts of a high intensity and extent only would be anticipated in the event of a catastrophic event such as a major landslide or release of fuel or chemicals from a truck having an accident near a major fish-bearing tributary, especially if it were to involve Getmuna or Crooked creek. The potential impact of such a scenario is described in Section 3.24, Spill Risk.

The Angyaruaq (Jungjuk) Port site would be constructed consistent with design standards and BMP requirements stipulated in the project's Title 16 Fish Habitat Permit. Construction would involve 26 acres where about 10,000 cy of dredged material along the Kuskokwim River shoreline would be removed to accommodate the berthing facilities. Construction of sheetpile infrastructure and fill activities would result in a temporary increase in suspended sediment from disturbance of the channel bottom. Once constructed, potential impacts are anticipated from changes in velocities and flow patterns occurring upstream, downstream, and across the channel from the sheet pile wall. This could create scour and depositional conditions which, in turn, could lead to increased channel and bank erosion near the structure causing sediment deposition downstream. Based on hydraulic modeling and existing site conditions, the proposed sheet pile wall design is predicted to alter the Kuskokwim River morphology at a low level of intensity relative to average annual peak flow and 100-year flood conditions. During 100-year flood events, however, potential eddy formation upstream from the sheet pile structure could occur that causes scour and bank erosion. Such impacts could be mitigated by bank protection as described in Chapter 5, Impact Avoidance, Minimization, and Mitigation (BGC 2014e). During operations, tugs would maneuver barges into the constructed berths where prop wash would disturb riverbed substrates and local populations of fish and aquatic biota. The resulting alteration of the shoreline character, loss of aquatic habitat, and disturbance of local fish populations would result in noticeable local impacts of a medium intensity that would extend over a long-term duration until site reclamation is completed during closure. The

context of such impacts would be important since aquatic habitat in the Kuskokwim River is regulated as EFH. As a result, anticipated overall impacts of the port site would be moderate.

Summary of Transportation Facilities Impacts

From construction to mine closure, anticipated impacts associated with truck and barge traffic along the mine access road and on the Kuskokwim River would range from low to high intensity. Following mine closure, the mine access road would remain in service, the port site would be reclaimed, and barge traffic would substantially diminish resulting in a reduced level of impacts to fish and aquatic resources in the Kuskokwim River and its tributaries. From construction to mine closure, impacts would occur on a local to regional scale, affecting resident fish and aquatic habitats common to the Kuskokwim River system. Additionally, anticipated impacts would affect the Kuskokwim River and certain tributaries in the Crooked Creek drainage that are regulated as EFH and considered important for sustaining life phases of several stocks of Pacific salmon under the Magnuson-Stevens Act. These fish stocks also are important to the Kuskokwim subsistence communities.

Along the Kuskokwim River, anticipated impacts would be primarily associated with hydraulic forces from vessel-generated wakes and propeller wash in certain confined and shallow segments of the navigation channel. Four of the five narrowest river segments surveyed in a 2014 study were located between Birch Tree Crossing and the Angyaruaq (Jungjuk) Port site (AMEC 2014). Depending on several considerations, hydraulic forces from barge traffic could result in:

- shoreline erosion and water quality degradation;
- fish displacement and stranding where channel segments at select shoreline locations having a low-gradient;
- habitat degradation from riverbed scour; and
- possible injury or mortality of egg, larval, or juvenile fish life stages that encounter propeller blades or shear forces in the propeller flow field in the water column or along the river bed.

Along the mine access road and at the port site, risks to fish and aquatic resources would be associated with construction and operation of roadways, bridges, culverts, and shoreline infrastructure. In the vicinity of these features, changes to the character of aquatic habitat and water quality would be noticeably altered resulting in long-term impacts on anadromous and resident fish populations and invertebrate communities. At certain locations along the mine access road, constructed road culverts could become periodically blocked. This could result in short-term barriers that temporarily obstruct fish passage until flows and fish passage conditions are properly restored.

Based on these considerations, potential direct and indirect impacts from tug and barge traffic, construction and operation of the mine access road, and port site development would range from negligible to moderate.

Incorporated Design Features

As described in Section 3.24, Spill Risk, all proposed marine and fuel storage operations would incorporate appropriate and required measures to minimize spill risks and other potential effects to aquatic resources including:

- Regularly surveying the Kuskokwim River navigation channel to identify locations that should be avoided to help prevent potential groundings;
- Implementing a loading system that considers real-time data on upstream water depths so that barges would be loaded appropriately to ensure sufficient draft while traveling upriver;
- Implementing BMPs for aquatic invasive species prevention, detection, and control;
- Implementing best practices for river navigation aids and operational procedures;
- Dedicating equipment that would remain on standby to free or unload/lighter barges in the event of potential groundings including sufficient standby capacity for fuel off-loading. Response equipment and staging would be located in the general vicinity where there is a high probability of groundings. Where appropriate, site-specific spill prevention and response plans would be developed and implemented.
- Exclusive use of double-hull barges for transporting fuel to shipping terminals; and
- Using secondary containment for the storage of all fuel and hazardous or dangerous materials at the shipping terminals, mine site area, and gas pipeline alignment during all phases of the proposed project to prevent potential releases from fuel handling, tank failures, or contaminated stormwater from reaching the aquatic environment.

These and other spill prevention and response measures have been incorporated into the proposed project and are described in greater detail in the Oil Discharge Prevention and Contingency Plan. In addition, all terms and conditions associated with required federal and state permits would be implemented to control potential impacts of the proposed project on fish and aquatic resources.

3.13.3.2.3 NATURAL GAS PIPELINE

Alternative 2 would involve construction of a 14-inch-diameter pipeline for transmission of natural gas from an existing 20-inch pipeline tie-in near Beluga, Alaska to the mine site approximately 315 miles to the west (SRK 2013b). Pipe and other heavy construction equipment would be shipped by ocean barge from terminals in Seattle, Washington or Vancouver, British Columbia to the Port of Anchorage, then to the Beluga barge landing resulting in a slight increase in shipping activity at the terminals.

Stream Crossings

The pipeline route planning process was based on a series of engineering and environmental criteria including the minimization of the number of stream and river crossings; avoidance of hydrological hazards; and minimization of overall work activities where construction would be particularly challenging. Potential construction effects on fish and fish habitat would be minimized by using site-specific stream crossing methods; limiting work to prescribed in-water

work windows; implementing construction BMPs and monitoring to ensure their effectiveness; and by using habitat restoration methods that provide an appropriate level of protection based on the species and habitat sensitivity that exists at each crossing (SRK 2013b). Specific BMPs will be developed during the final design and permitting process in cooperation with resource agencies.

Alternative methods evaluated for each river or stream crossing include horizontal directional drilling (HDD); open-cut dry flume; open-cut dam and pump; flowing water open-cut; non-flowing water open-cut; and small creek crossing. Where feasible, crossings would be constructed using open-cut methods that would be appropriate for three different types of waterbodies: 1) smaller drainages, intermittent streams and ditches, and non-sensitive water bodies where potential impacts from sedimentation are not anticipated; 2) frozen rivers or streams in winter where there is no surface flow; and 3) rivers/streams that are so large that no isolation method is feasible. The third method would depend on several factors including whether the crossing would occur in summer or winter, flow volume and velocity, type of bed material, and the width, depth, and amount of cover to be excavated/replaced.

Proposed large river winter open-cut crossings are currently proposed on the South Fork Kuskokwim River (MP 146.5), Big River (MP 191), Middle Fork of the Kuskokwim River (MP 182.7), Windy Fork (MP 168), Sheep Creek (MP 156.3), and Tatlawiksuk River (MP 217.5). The Tatina River crossing (MP 127.3) is proposed as a summer open-cut crossing. Open-cut crossings of large rivers or streams would involve excavation of the trench through the waterbody using backhoes operated from the riverbank or within the waterbody if it is too wide. Braided rivers would require backhoe operators to install a channel diversion prior to excavating the pipeline trench. The selection of site-specific open-cut methods and BMPs would be determined during final design and confirmed at the time of construction consistent with permit approvals (SRK 2013b).

HDD methods would be implemented based on a site-specific HDD Plan that would include a Drilling Mud Disposal Plan for management and disposal of drilling cuttings and drill mud. All pipeline stream crossing activities would be subject to environmental monitoring inspections during construction. Following construction, performance monitoring would continue as stipulated in the Surveillance and Monitoring Plan (SRK 2013b).

Currently, HDD is proposed at six of the major river crossings (Skwentna River at MP 50, Happy River at MP 86, Kuskokwim River at MP 240, East Fork of the George River at MP 283, George River at MP 290, and North Fork of the George River at MP 298). The length of the HDD crossings would range from 2,957 feet (George River) to 7,101 feet (Kuskokwim River). Entrance and exit bell hole locations at HDD crossings would each require 1.4 acres. All other crossings would be constructed using one of the open-cut methods previously mentioned with two-thirds of these constructed during winter. Subject to final design, additional stream crossings currently planned for open-cut methods may be constructed using HDD. The selection process for proposed HDD crossings is based on:

- Whether the river was of substantial size that would present engineering or other challenges to conventional open cut trenching;
- Whether HDD would be technically feasible based on current technology;
- Whether substantial traffic would be expected on the river;

- Whether construction for HDD (or alternatively trenching) would occur in summer or winter;
- Whether there are any specific environmental/engineering considerations or constraints that would mandate evaluation of HDD; and
- Other potential environmental, engineering, schedule, or cost considerations for HDD (SRK 2013b).

Along the pipeline route, a compressor station would be constructed at MP 0.4. With the exception of two aboveground fault crossings that would extend over a distance of about 1,300 feet, the rest of the pipeline would be installed below ground. Construction would take place within an operational ROW about 50 feet wide along most of the route. The operational ROW would be slightly wider in certain locations to accommodate the compressor station and other related facilities. As compared to the operational ROW, the construction ROW would require clearing that typically would be up to 150 feet wide with additional width in certain areas for staging of equipment and supplies. Campsites near major stream crossings along the pipeline ROW would require additional area ranging from about 8 to 22 acres not including airstrip or additional contractor laydown space. For example, the west and east camps on the Kuskokwim River at MP 247 and 234.8 would each support 300 workers and would require 16.3 and 21.8 acres, respectively. The Big River camp at MP 192 would support a similar number of workers and would require 12.4 acres (SRK 2013b).

Stream crossings of 100 feet or more in length would occur at 23 locations along the pipeline alignment. Approximately 20 stream crossings would occur in permafrost terrain with potential vulnerability to erosion both during and post-construction. Construction methods and BMPs to be implemented at anadromous and resident fish-bearing streams would be conducted consistent with requirements of the project's Title 16 Fish Habitat Permit. Where ephemeral waterways (with seasonal, intermittent flows) are crossed, the pipeline would be installed with a 4-foot depth of cover. This would be increased to 10 feet at perennial stream crossings with year around flow to provide scour protection.

During pipeline construction, some blasting would be required along the ROW primarily associated with material borrow sites. All blasting would be conducted in compliance with the Title 16 Fish Habitat Permit and the Alaska Blasting Standard for the Proper Protection of Fish (Timothy 2013). As previously described for the mine site area, this would include a suite of BMPs that would be finalized during the design and permitting processes to avoid, minimize, or mitigate impacts on all life stages of fish. Additional information regarding the nature and extent of soil disturbance from pipeline construction is described in Section 3.2, Soils.

All of the major drainages (Cook Inlet, Skwentna, Yentna, and Kuskokwim) to be crossed by the pipeline ROW and associated access roads contain mainstem channels and tributaries classified as EFH under the Magnuson-Stevens Act. While HDD could essentially avoid potential impacts to Pacific salmon EFH at the six crossings where this method is currently proposed, open-cut pipeline construction would require crossing of streams inhabited by anadromous or resident fish populations during sensitive seasons, including winter. Construction at such crossings would be based on site-specific plans and design measures that would minimize potential impacts to fish migration, rearing, and spawning activities and aquatic habitats. This would primarily occur by isolating the in-water work area from surrounding waters and, where

practical, removing and transferring fish to downstream waters prior to construction. Alternative design approaches would be based on one or more of the following:

- Crossing beneath large rivers using HDD;
- Damming and pumping streams around crossing sites;
- Diverting streams to dewater crossing sites;
- Crossing streams when they are completely frozen;
- Fluming streams through temporary culverts while installing the pipeline beneath the culvert; and
- Surveying for fish overwintering areas in order to avoid direct and indirect impacts to these locations (SRK 2013b).

Construction methods and BMPs for general erosion control and stormwater management within the ROW and at stream crossings would be implemented and monitored to control impacts to fish and aquatic habitat from a range of activities including streambed excavations and pipeline burial, temporary fish passage obstructions during stream bypasses, riparian vegetation removal during clearing and grading activities, and potential releases of drilling mud (fluid). Following construction, restoration of disturbed areas along streams and other aquatic areas would be restored based on a suite of methods to be developed during final design and permitting including those described by Walter et al. (2005). Erosion and sediment control BMPs are described in Section 3.5.3.2.3, Surface Water Hydrology.

Three HDD river crossings are planned for summer (those involving the George River) while the other three crossings (Kuskokwim River, Skwentna River, and Happy River) are planned for winter. Should HDD prove unsuccessful at any of these crossings, the construction schedule would allow for a re-attempt using the same or alternative methods.

A frac-out release at HDD crossings could occur whereby non-toxic drilling mud unintentionally seeps into overlying waters through unconsolidated gravel, coarse sand, and fractured bedrock. The HDD Operations Plan would require monitoring for any substantial drop in pressure or mud return that could indicate a frac-out has occurred. In such an event, drilling would be immediately halted until the situation has been resolved. Frac-out releases could result in temporary, local increases in turbidity and sedimentation from bentonite dispersed along the riverbed downstream of the crossing. Depending on the nature, location, and duration of the release, a medium to high level intensity of impacts to streambed gravels, anadromous and resident fish populations, and other aquatic biota could occur. Monitoring-specific BMPs at HDD construction sites would be conducted to prevent and assess potential frac-out incidents. This would include inspecting pressure levels on drilling fluids to ensure they are set as low as possible to match the formation being drilled in order to avoid or minimize potential frac-out occurrences. Further information on the prevention, detection, and response related to potential frac-out or drilling fluid release will be described in the HDD Plan and the SPCC Plan that would be finalized during final design and permitting. This would include procedures to be implemented in the event of potential HDD abandonment and use of alternative open-cut methods at locations where HDD was intended. Sections 3.5, Surface Water Hydrology; and 3.7, Water Quality, provide additional information regarding construction BMPs for water quality protection.

East of the proposed pipeline crossing of the upper Kuskokwim River, the pipeline route would cross the Big River, a tributary whose confluence is located upriver of McGrath. The Big River has been documented as a key spawning tributary for sheefish, broad whitefish, and humpback whitefish based on radio-tag tracking studies conducted from 2007 to 2011 (Stuby 2012; Harper et al. 2012). Results of these and others studies (Alt 1979) indicate historic spawning areas occur about 30 miles downstream of the proposed pipeline crossing and also may extend farther upstream. Based on these investigations, sheefish annually arrive at their spawning areas on the Big River from late July through mid-September and spawn between late September through early October. After spawning, sheefish migrate downriver in mid-October where they overwinter in the lower or middle Kuskokwim River. Broad whitefish were found to spawn in late October to early November while humpback whitefish spawned in early October with both species returning downstream where they overwintered in the mainstem Kuskokwim River. This suggests that proposed stream crossing activities that are scheduled to occur outside the period of July to early November would avoid disturbance of spawning activities although eggs would remain in the gravels for several months thereafter. In June, local residents annually harvest sheefish from this area as these fish begin their upstream spawning migration from the Kuskokwim River. Since sheefish are one of the first species to return to the area in early spring, the fishery provides an initial source of fresh fish prior to the return of salmon runs.

As previously described, winter open-cut stream crossings would involve several major rivers and tributaries including the South Fork Kuskokwim River. A variety of salmon and non-salmon species are associated with waters where crossings would occur (Table 3.13-22). One of these species, burbot, is a long-lived and slow growing resident fish that typically completes its life cycle in freshwater and requires 5 to 7 years to reach sexual maturity. Within the Kuskokwim River basin, burbot populations are considered robust where they are an important component of the local subsistence fishery. Dense concentrations of mature adults are often caught under the ice as they gather to spawn over fine gravel, sand, and fine silt in late winter in low-velocity waters in main channels and side channels. Spawning generally occurs over a brief 2 to 3 week period where milt and semi-buoyant eggs are broadcast into the water column and eventually settle into interstitial spaces of riverbed substrates to incubate. Egg incubation lasts 41 to 128 days depending on water temperatures (McPhail and Paragamian 2000). Winter open-cut stream crossings that would occur in areas frequented by concentrations of adult spawning burbot could disturb spawning activities causing these fish to seek other suitable areas for spawning. Trenching during winter months when burbot eggs are incubating could impact egg survival from direct disturbance or from sedimentation of the riverbed along the crossing or in waters immediately downstream. Because burbot are relatively slow growing, potential impacts to adults or eggs from winter open-cut construction could require a long time for affected populations to recover.

Two other resident fish species that also can be important components of subsistence and sport fisheries in the Kuskokwim basin include northern pike and Arctic grayling. Northern pike often overwinter in deep, slow waters of the mainstem Kuskokwim and its major tributaries. Spawning occurs in spring, soon after ice-out occurs, when adults migrate to tributaries and subsequently return to warm, shallow, summer feeding areas in the same general area. During the summer of 2014, subadult northern pike were captured in nearshore waters of the mainstem Kuskokwim River and often were observed within off-channel backwaters and side channels of the mainstem channel (Owl Ridge 2014b).

Arctic grayling, a common resident species within the Kuskokwim basin, also spawns in spring. Like burbot, Arctic grayling is a long-lived species that overwinters in deep pools in mainstem channels. It is a broadcast spawner that migrates upstream to spawn soon after ice-out. Eggs, which typically are spawned over pebbles and gravel substrates, incubate for about three weeks after which time fry migrate to nearshore waters for rearing in shoreline edge habitat. Juvenile grayling comprised the third most abundant species captured during nearshore fish surveys in the Kuskokwim River during the early summer of 2015 (Owl Ridge 2015b). Open-cut stream crossings that occur in spring that affect tributaries and small off-channel streams and backwaters could adversely impact northern pike and Arctic grayling spawning habitat and could disturb spawning activities causing these fish to seek other suitable spawning areas. Spring open-water trenching during periods when eggs are incubating could impact egg survival for these fishes from direct disturbance or from sedimentation of the riverbed along the crossing or in waters immediately downstream.

Public Access

During construction, a “controlled access” policy would be implemented along the pipeline ROW to manage public access and safety and avoid construction hazards. Notices and warning signs, flagging, barricades, and other safety measures would be used to coordinate and manage public access during construction through closure phases to protect the public, sensitive environments, and fish and wildlife populations from potential impacts. The Donlin Gold Public Outreach Plan would inform the public regarding the nature and extent of such measures. Throughout all phases of the project, employees and contractors of Donlin Gold would be prohibited from operating project-related equipment off the pipeline ROW or any other temporary use areas or material borrow sites. In addition, Donlin Gold would prohibit its employees and contractors from hunting, fishing, trapping, shooting, and camping within or adjacent to the pipeline ROW or using equipment for those purposes while in the project area for work-related purposes (SRK 2013b).

Although limited potential exists for general public access to the pipeline corridor due to the remoteness of the area and seasonal transportation constraints, temporary construction roads, maintenance road improvements, and ATV use near rivers and streams along the gas pipeline could increase fishing access to area streams beyond existing conditions. Such access improvements could benefit the local subsistence community but also could increase competition from the sport fishing community from within and outside the area for salmon and non-salmon species including whitefish, burbot, rainbow trout, Dolly Varden, Arctic grayling, and northern pike. Table 3.13-22 provides a summary of fish species that exist in affected drainages along the gas pipeline ROW. Additional information on public access relative to fishing and hunting and potential water quality impacts is provided in Sections 3.21, Subsistence; 3.16, Recreation; and 3.7, Water Quality.

Water Withdrawals and Releases

Potential construction impacts along the natural gas pipeline also could result from the withdrawal of water from local ponds, tributaries, rivers, and streams for development of temporary ice roads, general water use, and for pipeline hydrotesting. Discharge of water and sediment to local drainages also would occur during pipeline hydrotesting. Tables 8-12 and 8-12a in the Donlin Gold Natural Gas Pipeline Plan of Development provide a preliminary list of potential water extraction sites relative to construction milepost, season of use, waterbody type,

years of use, and extraction rate and quantity (SRK 2013b). While water withdrawals and releases have the potential to affect local water levels, stream flows, and water quality, and fish habitat, these activities would be conducted consistent with requirements specified in ADNR water withdrawal permits, ADF&G Title 16 Fish Habitat Permits, and ADEC water discharge permits. These permits would establish fish-protection measures relative to screening of pump intakes, the locations and amounts of water that could be withdrawn from various sources, and water quality discharge requirements. The rate and volume of water withdrawals and discharges would be monitored for permit compliance at each approved supply source and discharge point to ensure aquatic habitat and fish populations in the affected streams are protected, particularly for reaches identified as having habitat important for egg incubation and overwintering. These and other considerations could restrict water withdrawals from certain streams or stream reaches for ice road construction as determined by future agency consultations during the water withdrawal and discharge permit review processes. Supplemental baseline surveys of the affected stream reaches where water withdrawals or discharges are proposed also may be required to identify and evaluate potential site-specific impacts that could require alternative locations so minimal impacts to fish populations and their habitat would occur.

Construction Impacts

Based on proposed design measures, BMPs, and compliance monitoring, potential impacts from pipeline construction on surface waters, aquatic habitats, and anadromous and/or resident fish populations may be noticeable and of a low to medium level of intensity. Pipeline and shoefly road aquatic invasive species impact risk is similar to that of the mine site. Tyonek Port site aquatic invasive species risk would also include marine aquatic invasive risk, and is similar to that of the transportation facilities impact. Activities involving pipeline installation, stream crossings, construction access roads, and water withdrawals and discharges for ice roads and pipeline hydrotesting would be temporary extending through construction, local in extent, and important in context involving EFH in many locations. The duration of construction at any single point along the 315-mile pipeline ROW would last about 3 to 4 months until final grading is completed. Over 68 percent of the pipeline construction would be scheduled during frozen winter conditions to reduce impacts of disturbance to soils and surface waters. Therefore, direct and indirect effects of pipeline construction on local fish populations and associated aquatic habitat in rivers, streams, and tributaries along the ROW would be minor.

Impacts of Pipeline Operation

During pipeline operations, all temporary construction access roads, storage yards, airstrips, and related facilities would be reclaimed. The portion of the construction ROW outside the operational ROW also would be reclaimed. Limited soil disturbance would occur periodically on a long-term basis over the 30 years of the pipeline's use as a result of maintenance access and related activities, operations at material borrow sites, ATV access, vegetation management, equipment removal and replacements, pipeline inspections, and ROW mitigation activities. Until disturbed soils are stabilized and reclamation has been completed with fully restored plant communities, runoff and stream sedimentation could result in potential adverse effects of a low to medium intensity to aquatic habitat and anadromous or resident fish populations. This would have an important context where streams are regulated as EFH. As a result, direct and

indirect effects of pipeline operation on local fish populations in affected tributaries along the pipeline ROW would range from minor to moderate.

Impacts of Pipeline Closure

During closure, in-place abandonment of the pipeline following purging would result in no effects on runoff, stream sedimentation, in-stream flows, or aquatic habitats along most of the ROW. Some soil disturbance and runoff could occur where above grade facilities are dismantled and removed. Nearby streams in such areas would be subject to potential runoff from disturbed soils until the areas of disturbance are stabilized, however, potential impacts would be minimized by established BMPs. Depending on the effectiveness of BMPs implemented where above grade facilities are removed, such activities could result in temporary adverse effects of a low to medium intensity to nearby aquatic habitat and anadromous or resident fish populations; some of which is regulated as EFH and has an important context. Therefore, direct and indirect effects of closure on local fish populations in affected tributaries along the pipeline ROW would be minor.

Summary of Natural Gas Pipeline Impacts

Anticipated effects from Alternative 2 would involve anadromous and/or resident fish populations and associated aquatic habitats downstream of certain pipeline crossings not crossed using HDD methods and along the construction ROW where it is aligned near and upgradient from local streams. Potential direct and indirect impacts related to habitat degradation could result from stormwater runoff, suspended solids, and altered flows caused by disturbed soils; water withdrawals for ice-road construction and pipeline hydrotesting; construction of stream crossings using open-trench methods; and water releases from pipeline hydrotesting. Overall, such impacts are anticipated to occur at a low to medium intensity based on implementation of construction BMPs and permit requirements including those to be specified in the Title 16 Fish Habitat Permit once final design is completed. Potential construction impacts would be temporary while those extending through operations, closure, and reclamation would occur over a long-term duration (over 30 years). Because of the 315-mile length of the proposed pipeline, the extent of potential impacts along the ROW would be regional in nature with a context that would be considered important for those reaches of affected streams at crossings or along the pipeline ROW that are classified as EFH under the Magnuson-Stevens Act. Therefore, potential direct and indirect impacts from pipeline construction; operation and maintenance; and closure, reclamation and monitoring would range from minor to moderate.

3.13.3.2.4 CLIMATE CHANGE SUMMARY FOR ALTERNATIVE 2

Predicted overall increases in temperatures and precipitation and changes in the patterns of their distribution (McGuire 2015, Chapin et al. 2010, Chapin et al. 2006, Walsh et al. 2005) have the potential to influence the projected effects of the Donlin Gold Project on wetland and water body habitats. Expected changes include species range shifts to fish tolerant of warmer waters; temporal shifts in prey and predators; food web alterations due to temperature and acidification changes; habitat changes such as turbidity increase; or shifts in run timing (ADF&G 2010b, IUCN 2009). Higher water temperatures increasing metabolic stress for fish species could result in lower tolerance thresholds to land-use impacts. A positive effect may be that a moderate

increase in water temperature could contribute to a more productive feeding season and enable fish to better survive the winter and additional stress. See Section 3.26, Climate Change, for further details on climate change and resources.

3.13.3.2.5 SUMMARY OF IMPACTS FOR ALTERNATIVE 2

The Impact Levels of Alternative 2 by Project Component and Impact Type are summarized in Table 3.13-30. Under Alternative 2, impacts to fish and aquatic resources would range from low to high intensity during construction and operation. Low intensity impacts could result from:

- limited riverbed scour and aquatic habitat degradation from tugs traveling along the wide sections of the Kuskokwim River navigation channel in depths greater than 10 feet;
- potential fish displacement or stranding along shorelines where the river channel is relatively wide or where the line of travel by barges is a relatively long distance from shore;
- tug propeller shear force-related fish injuries or mortalities when small young-of-year fish are widely dispersed and not concentrated near barge traffic in confined channel segments along the navigation route;
- water management and water quality effects in lower reaches of Crooked Creek below the Crevice Creek confluence, well downstream from the mine site area; and
- habitat degradation along the mine access road and most of the natural gas pipeline alignment.

Impacts of a medium to high level of intensity could result from:

- streamflow reduction and sedimentation that cause local effects to fish populations and aquatic habitat in Crooked Creek and its tributaries in the vicinity of the mine site area;
- barge traffic waves and turbulence that could displace or strand young-of year salmon or degrade shoreline water quality along shorelines of confined segments of the Kuskokwim River navigation channel (four of five of the narrowest channel segments are located at or upriver from Birch Tree Crossing);
- riverbed scour and degradation of aquatic habitat, in areas utilized for rainbow smelt spawning and egg-incubation in late May and June as a result of tug propeller forces along the navigation channel where depths are shallow and generally less than about 8-10 feet; and
- potential injuries or mortalities from tug propeller shear forces when small young-of-year salmon or resident fishes are migrating in dense concentrations, particularly where barge traffic is passing through constricted channel segments of the river.

Table 3.13-30: Impact Levels of Alternative 2 by Project Component and Impact Type

Impact- causing Project Component	Magnitude or Intensity	Duration	Geographic Extent	Context	Summary Impact*
Mine Site					
In-stream habitat removal and fish loss	American Cr. – High Lewis Gulch – Med Anaconda Cr – High Snow Gulch – Med Omega Gulch – Med	Permanent Permanent Permanent Permanent Permanent	Local Local Local Local Local	Important Common Important Common Common	Moderate Minor Moderate Minor Minor
Water management practices	MSA Tributaries - Med Crooked Creek- Low	Permanent Permanent	Local Local	Important Important	Minor Minor
Water quality practices	Low	Permanent	Local	Important	Minor
Wetland and Riparian Buffer Removal	Medium to High	Short to Long-term	Local	Important	Moderate
Streamflow changes and overall aquatic habitat	Mid Reaches – Med Lower Reaches – Low Mid and Lower Reaches Under <i>High K</i> Scenario - High	Long-term Long-term Long-term	Local Local Local	Important Important Important	Moderate Minor Major
Streamflow changes to off-channel aquatic habitat	Mid Reaches – Low to Med Lower Reaches – Low Mid/Lower Reaches <i>High K</i> Scenario - High	Long-term Long-term Long-term	Local Local Local	Important Important Important	Moderate Minor Major
Streamflow changes and mainstem aquatic habitat	Medium <i>High K</i> scenario - High	Long-term Long-term	Local Local	Important Important	Moderate Major
Streamflow changes and salmon spawning habitat	Medium <i>High K</i> scenario - High	Long-term Long-term	Local Local	Important Important	Moderate Major
Streamflow changes and freezing of salmon spawning substrate	Middle Reaches – Low Lower Reaches - Negligible Mid/Lower Reaches <i>High K</i> scenario - High	Long-term Long-term Long-term	Local Local Local	Important Important Important	Minor Negligible Major
Streamflow changes and Crooked Creek salmon production	Middle Reaches – Medium Lower Reaches - Negligible Mid/Lower Reaches <i>High K</i> scenario - High	Long-term Long-term Long-term	Local Local Local	Important Important Important	Moderate Negligible Major
Stream temperature changes in Crooked Creek	Near MSA - Low to Medium Lower Crooked Creek - Low	Permanent Permanent	Local Local	Important Important	Minor to Moderate Minor

Table 3.13-30: Impact Levels of Alternative 2 by Project Component and Impact Type

Impact- causing Project Component	Magnitude or Intensity	Duration	Geographic Extent	Context	Summary Impact*
Erosion & sedimentation	Low to Medium	Long-term	Local	Important	Minor to Moderate
Methylmercury emissions	Low in wetlands	Long-term	Regional	Important	Minor to Moderate
	Medium in water	Long-term	Regional	Important	Minor to Moderate
Contamination and Fuel Spills	Low	Long-term	Local	Important	Minor
Transportation Infrastructure					
Vessel wave energy impacts on nearshore erosion, turbidity, water temperature	Turbidity – Low Water Temp – Low	Long-term Long-term	Local Local	Important Important	Minor Negligible to Minor
Fish displacement and stranding	Low to Medium	Long-term	Local	Important	Negligible to Moderate
Prop wash scour of riverbed substrates and fish spawning gravels	Medium to High	Long-term	Local	Important	Moderate to Major (in shallow, narrow channels)
Propeller-induced fish injury and mortality	Low to High	Long-term	Local	Important	Negligible to Moderate
Mine access road construction, operations, and maintenance	Road work and stream crossings - Low to Medium Rock blasting – Low Ice roads – Low to Medium	Long-term Short-term Short-term	Local Local Local	Important Important Important	Minor Minor Minor
Port site construction and operation	Medium	Long-term	Local	Important	Moderate
Contamination and Fuel Spills	Low	Long-term	Local	Important	Minor
Pipeline					
Stream crossings, water withdrawals and discharges from ice road construction and pipeline testing	Low to medium	Temporary	Local	Important	Minor
Construction and operation of pipeline and related infrastructure	Low to medium	Long-term	Regional	Important	Minor to Moderate

Table 3.13-30: Impact Levels of Alternative 2 by Project Component and Impact Type

Impact- causing Project Component	Magnitude or Intensity	Duration	Geographic Extent	Context	Summary Impact*
Closure and reclamation	Low to medium	Temporary	Local	Important	Minor
Contamination and Fuel Spills	Low	Long-term	Local	Important	Minor

Notes:

* The summary impact rating accounts for impact reducing design features proposed by Donlin Gold and Standard Permit Conditions and BMPs that would be required. It does not account for additional mitigation measures the Corps is considering.

The extent of direct and indirect impacts would be regional and important in context involving anadromous and resident fish populations and EFH in Crooked Creek and its major tributaries and along the Kuskokwim River at constricted and shallow channel segments. On a conservative basis, the net over all impacts, therefore, would range from moderate to major.

These effects determinations take into account impact reducing design features (Table 5.2-1 in Chapter 5, Impact Avoidance, Minimization, and Mitigation) proposed by Donlin Gold and also the Standard Permit Conditions and BMPs (Section 5.3, Impact Avoidance, Minimization, and Mitigation) that would be implemented. Several examples of these are presented below.

Design features most important for reducing impacts to fish and aquatic resources include:

- The project design includes (when practicable) crossing drainages at right angles to reduce riparian impacts, and use of bridges. The intent of this design feature is primarily to minimize footprint in riparian areas;
- Ocean and river fuel barges would be double hulled and have multiple isolated compartments for transporting fuel to reduce the risk of a spill;
- The barge operations system was designed to avoid the need for river dredging;
- Approximately 68 percent of the total pipeline length would be constructed during frozen winter conditions to minimize wetland and soil disturbances from support equipment. Areas selected for summer or fall construction would be based on geotechnical, terrain, safety, and continuity considerations; and
- The project design includes use of BMPs at pipeline stream crossings to minimize alterations of the stream bed and bank erosion. It also includes design of pipeline depth of burial at stream crossings to avoid scour exposure of the pipe.

Standard Permit Conditions and BMPs most important for reducing impacts to fish and aquatic resources include:

- Implementation of SWPPPs and/or ESCPs;
- Monitoring of water withdrawals to ensure permitted limits are not exceeded;
- Verification that Project vessels are equipped with proper emergency towing equipment in accordance with 18 AAC 75.027(f), with 18 AAC 75.027(f); and
- An Invasive Species Management Plan (ISMP).

Additional Mitigation and Monitoring for Alternative 2

The Corps is considering additional mitigation (Table 5.5-1 in Section 5.5, Impact Avoidance, Minimization, and Mitigation) to reduce the effects presented above. These additional mitigation measures include:

- Specific plans for borrow site reclamation would be completed in a later phase of the project. In addition to standard BMPs for contouring, drainage, and erosion controls (Section 3.2, Soils), reclamation should consider creating ponds and/or stream connections for fish and wildlife habitat at borrow sites in low lying areas (e.g., at Getmuna Creek) in accordance with ADEC and ADF&G guidance (Shannon & Wilson 2012; McClean 1993).

The Corps is considering additional monitoring (Table 5.7-1 in Section 5.7, Impact Avoidance, Minimization, and Mitigation) to reduce the effects presented above. These additional monitoring measures include:

- Monitor Donlin tug-barge passages during the first years of construction to assess potential effects of barge traffic on riverbed scour, bank erosion, and nearshore velocities at variable depths and channel configurations, as well as fish habitat and fish passage.

If needed, effects analysis of barge passage impacts would provide a basis for potential adaptive management.

- Monitor potential effects of barge traffic and natural environmental parameters on rainbow smelt spawning areas. Should potential impacts of barge traffic be documented, consider adaptive management measures to minimize impacts on rainbow smelt such as directing barge traffic to deeper portions of the river channel while traveling in the vicinity of previously identified rainbow smelt spawning grounds between mid-May and late June depending on the annual timing of peak spawning activity. Monitoring of both physical environment impacts (e.g., water parameters) and biological impacts (fish spawning locations, etc.) associated with the range of potential barge impacts would allow clearer answers to adaptive management questions.

Based on monitoring results, consider mitigation measures such as reduced barge speed during critical fish spawning and larval migration periods, to minimize prop scour impacts.

- Coordinate construction and operations phase fish population and water quality monitoring with agencies or working groups (such as the Kuskokwim River Salmon Management Working Group).

Continue baseline Project fish and water quality studies to help track possible incremental impacts for development adaptive management strategies as necessary if impacts occur beyond what are expected.

- Monitor fish and aquatic habitat along the barge route upstream of Bethel during the barging season to assess potential changes in habitat. If warranted, specific adaptive management measures to reduce adverse impacts would be considered.

Monitoring would take into account current estimated barge traffic type and volume.

As a condition of permitting, additional pre-construction baseline analysis of fish and aquatic resource habitat along the barge transport route should be conducted.

Predicting the level of potential effects on fish and aquatic resources requires additional analyses based on the type of tug and barge combinations proposed for the project in order to assess the locations, magnitude, character, and extent of vessel-generated turbidities.

- Monitor fish as well as water quality during reclamation and post-closure in Crooked Creek.

Both physical (water quality) and biological (fish, wetlands) resources should be identified for monitoring during all Project phases (construction, operations, and closure).

Contingency measures (adaptive management) should be developed and defined if impacts occur beyond what are expected.

If these mitigation and monitoring measures were adopted and required, the summary impact rating for the mine site would be somewhat reduced, but would remain moderate to high. The impacts from the transportation facilities and the natural gas pipeline would also be somewhat reduced, but would remain minor to moderate.

3.13.3.3 ALTERNATIVE 3A – REDUCED DIESEL BARGING: LNG-POWERED ROCK TRUCKS

3.13.3.3.1 MINE SITE

Under Alternative 3A, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the mine site based on the use of LNG-powered rock trucks would be similar to that described for Alternative 2.

3.13.3.3.2 TRANSPORTATION FACILITIES

Due to the proposed use of LNG-powered rock trucks under this alternative, less diesel fuel would be required at the mine site. This would reduce by about two-thirds (from 58 to 19 trips) the number of fuel barge trips from Bethel to the Angyaruaq (Jungjuk) Port site on the Kuskokwim River. Fuel shipments from Dutch Harbor to Bethel also would be reduced by about two-thirds (from 14 to 5 trips). Fewer barge trips would result in a proportionate reduction in the amount of tug and barge-generated wakes, prop wash, and riverbed scour that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations in the mainstem of the Kuskokwim River. The reduction in the number of trips by tug and barge combinations would nearly eliminate requirements for travel during low flow conditions. As a result, effects described above from barge traffic on migrating and rearing fish in confined and shallow sections of the navigation channel would be reduced. While the range of magnitude, duration, extent, and context of impacts would be similar to that described for Alternative 2, the probability of such impacts occurring would be proportionately reduced.

3.13.3.3.3 NATURAL GAS PIPELINE

Under Alternative 3A, direct and indirect effects to fish and aquatic resources from construction, operation, and abandonment/closure of the natural gas pipeline would be the same as described for Alternative 2.

3.13.3.3.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 3A

Since the amount of fuel barge trips on the Kuskokwim River would be reduced by two-thirds under Alternative 3A, the anticipated level of impacts from barge traffic and accidental releases of fuel would be less than Alternative 2. Therefore, the net overall direct and indirect impacts for Alternative 3A would be minor. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. If mitigation and monitoring measures from Alternative 2 were adopted and required, the summary impact rating for the mine site and transportation facilities would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The impacts from the transportation facilities and the natural gas pipeline would remain minor to moderate.

3.13.3.4 ALTERNATIVE 3B – REDUCED DIESEL BARGING: DIESEL PIPELINE

3.13.3.4.1 MINE SITE

Under Alternative 3B, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the mine site based on delivery of fuel from a diesel pipeline would be similar to that described for Alternative 2.

3.13.3.4.2 TRANSPORTATION FACILITIES

Under Alternative 3B, diesel fuel would be shipped via ocean barges to Tyonek at the eastern terminus of the diesel pipeline while cargo would be transported to the mine site, as described under Alternative 2, via the Kuskokwim River and mine access road. This would reduce or eliminate the need for additional diesel fuel storage described under Alternative 2 at the ports of Dutch Harbor, Bethel, and Angyaruaq (Jungjuk). During construction of the Angyaruaq (Jungjuk) port site, mine access road, and mine site, diesel fuel would need to be transported by barge to the Angyaruaq (Jungjuk) port site. During operation, the delivery of diesel fuel to the mine site via the diesel fuel pipeline, instead of by barge on the Kuskokwim River, would reduce the peak annual barge traffic on the Kuskokwim as described under Alternative 2 by 47.5 percent or equivalent to about 0.6 round trips per day instead of 1.1 trips per day. This would still represent a measureable increase in barge traffic of about 147 percent over existing levels of 68 barge tows per year. The larger diameter pipe would require more barge trips during construction to deliver the pipe.

Similar to Alternative 3A, fewer barge trips on the Kuskokwim River would result in a proportionate reduction in the amount of tug and barge-generated wakes and prop wash that could adversely affect water quality, aquatic habitats, and anadromous and resident fish populations. The reduction in the number of trips would nearly eliminate requirements for travel during low flow conditions. As a result, effects of prop wash scour from barge traffic on

migrating and rearing fish in confined and shallow sections of the navigation channel would be reduced. While the range of the magnitude, duration, extent, and context of impacts would be similar to that described for Alternative 2, the probability of such impacts occurring would be proportionately reduced.

3.13.3.4.3 DIESEL PIPELINE

An 18-inch (vs. 14-inch under Alternative 2) diameter pipeline would be buried in a 334-mile (vs. 315-mile for Alternative 2) corridor along a similar alignment as Alternative 2. An additional segment, however, would be constructed between the improvements at the Tyonek North Foreland Facility and the start of the corridor at Beluga as described under Alternative 2. Because there would be a small incremental increase in additional ROW and off-ROW disturbed areas under Alternative 3B compared to Alternative 2 (from 14,100 to 15,000 acres or 6 percent), there would be a larger, but similar level of local effects from erosion and runoff that would range from low to high intensity. Increased disturbance would include an additional 700 acres for construction of ROW from Tyonek to Beluga. Associated impacts to local streams and drainages from erosion and runoff would be limited, to the extent possible, by erosion and sediment control BMPs. Potential effects to anadromous and resident fish and aquatic resources along the pipeline ROW and in off-ROW areas due to construction and closure, therefore, also would be similar to Alternative 2. Additional cargo and fuel, however, would need to be delivered to the Tyonek Forelands terminal for construction of the proposed fuel terminal and pipeline that would extend from Tyonek to Beluga. During operations, an additional 24 barge trips would arrive at the terminal annually. Potential impacts on fish and aquatic resources near the terminal from the additional barge arrivals are anticipated to be minor. Therefore, anticipated overall impacts from construction, operation, and abandonment of the diesel pipeline would be minor unless there was an accidental discharge of diesel fuel to local streams which is evaluated under Section 3.24, Spill Risk.

3.13.3.4.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 3B

While fuel barge trips on the Kuskokwim River during the operations and maintenance phase would be eliminated under Alternative 3B, the sources and level of impacts during construction would be similar to Alternative 2, and the impacts associated with the access roads would be longer lasting. The net overall direct and indirect impacts for Alternative 3B would be minor to moderate. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. If mitigation and monitoring measures from Alternative 2 were adopted and required, the summary impact rating for the mine site and transportation facilities would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The impacts from the transportation facilities and the natural gas pipeline would remain minor to moderate.

3.13.3.5 ALTERNATIVE 4 – BIRCH TREE CROSSING (BTC) PORT

3.13.3.5.1 MINE SITE

Under Alternative 4, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the mine site based on delivery of fuel and cargo from BTC Port site would be similar to that described for Alternative 2.

3.13.3.5.2 TRANSPORTATION FACILITIES

Under Alternative 4, barge traffic from Bethel would travel about 99 miles upriver to the BTC Port site but would not be required to travel the additional 69 miles to the Angyaruaq (Jungjuk) Port site as proposed under Alternative 2. While this would involve a shorter over-water travel route, it would require the same number of tows, but over fewer days of traffic, since the same amount of cargo and fuel still would be required at the mine site during construction, operations, and closure under both alternatives. Since the Kuskokwim River channel is more confined upriver of the BTC Port site (four of five of the narrowest channel segments are located at or above Birch Tree Crossing), the intensity of impacts resulting from barge traffic relative to hydraulic forces from vessel wakes and prop wash on shorelines would be reduced in intensity. In addition, communities upriver of the BTC Port site including Aniak, Chuathbaluk, Napaimute, would not experience an incremental increase in barge traffic from the proposed project as otherwise would occur under Alternative 2. Therefore, potential impacts of vessel wave energy on water quality and fish displacement/stranding during construction, operations, and closure would be reduced to a range of negligible to minor; potential impacts from tug propeller forces on bed scouring and aquatic habitat that could affect rainbow smelt spawning areas would remain moderate to major; and tug propeller forces on fish injury or mortality would be reduced to a range of negligible to minor. Overall, water transportation impacts on fish and aquatic habitat would range from negligible to major based on a medium to high level of impact intensity that would occur over the long-term duration of the proposed project on a regional basis (from BTC to Kuskokwim Bay). The context of such impacts would be important since all waters along the Kuskokwim River navigation channel, from Kuskokwim Bay to BTC and farther upriver, are regulated as EFH under the Magnuson-Stevens Act.

A single-season 12-mile ice road would be developed during construction from Crooked Creek Village to the mine site vicinity along Crooked Creek valley as a temporary late-winter access to material borrow sites for road construction. The ice road would be constructed to minimize impacts to underlying vegetation, soils, and drainages by implementing guidelines and management practices that have been established for state and federal lands. Recent improvements in BMPs have shown that construction and use of single-season ice roads can minimize vegetation and soil impacts when routes are properly selected and appropriate construction methods are used by equipment operators (ADNR 2010). Subject to the Title 16 Fish Habitat Permit, water for ice road construction would be withdrawn from approved stream segments using screened pump intakes to prevent injury or death to fish. Water withdrawals would be prohibited in areas where streams freeze completely to the bottom to avoid draining isolated unfrozen pools in the area that may hold overwintering fish. Because vegetation types associated with soils along the anticipated route are not ideal for ice road construction, the landscape and local drainages could be adversely affected at a low to medium level of intensity. Degradation of soils and drainages could temporarily affect water quality and

in-stream habitat, resulting in local adverse effects to fish and aquatic resources until the routes are sufficiently stabilized. The context of potential impacts to Crooked Creek would be important since it is regulated as EFH. The single-season use of the ice road should minimize potential long-term effects that might otherwise occur from multi-season use.

A new two-lane, 30-foot-wide, all-season gravel-surfaced mine access road would be constructed from the BTC Port site to the mine site. This 73-mile long road would be about 43 miles (2.5 times) longer than the 30-mile long road proposed under Alternative 2 that would connect the Angyaruaq (Jungjuk) Port site with the mine. The longer mine access road from the BTC Port site would require about 900 acres of soil disturbance versus 400 acres required under Alternative 2. The transport of materials on the longer road would require roughly twice as many truck trips to deliver materials because of the longer transit time.

The nature of potential impacts from erosion and sedimentation that could affect local streams crossed or downgradient from the ROW in the Owhat River drainage during construction and long-term maintenance of the access road, bridges, and culverts would be similar to Alternative 2. Also similar to Alternative 2 are that construction and operations activities would be managed and monitored by implementing a suite of BMPs that would be installed and monitored along the road corridor and at all stream crossings to ensure they reduce the intensity of runoff, erosion, and sediment loads and minimize potential impacts to fish, other aquatic life, and their habitats.

Periodic, temporary barriers to fish passage could occur over all phases of the project continuing through post-closure monitoring. The intensity of impact to fish populations is expected to be low to medium but would depend on the nature and magnitude of potential blockage incidents and the timing required to properly restore flows and fish passable conditions. Although 43 miles longer than the access road proposed under Alternative 2, preliminary field reconnaissance indicates the route between the BTC Port site and the mine would cross 40 streams, 10 fewer than the number crossed for Alternative 2. Of the streams crossed, 8 would involve bridges while 32 would involve culverts (Alternative 2 would require 5 bridges and 45 culverts). The Owhat River and the lower reaches of several of its tributaries are classified as EFH under the Magnuson-Stevens Act. Similar to Alternative 2, potential impacts to anadromous and resident fish populations and EFH would be of a medium intensity and noticeable at certain times and locations, affecting localized sections of drainages downgradient of stream crossings on a long-term basis. The access road, bridges, and culverts all would need to be maintained in perpetuity to support ongoing post-closure monitoring.

In addition to construction of the mine access road, development of the BTC Port site would require disturbance of about 65 acres or nearly twice as much area as would be required for the Angyaruaq (Jungjuk) Port site under Alternative 2. Similar to Alternative 2, port construction at BTC would result in aquatic habitat loss related to removal and upland disposal of about 10,000 cubic yards of dredge material from the Kuskokwim River for construction of shoreline infrastructure including sheetpile walls and berthing features. Impacts associated with the mine access road and port site, therefore, would likely result in minor impacts on fish and aquatic resources, however, there would be a higher probability of such impacts occurring due to the road distance being twice as long as Alternative 2. Similar to Alternative 2, however, since bedscour from tug propeller forces could adversely affect rainbow smelt eggs incubating in spawning gravels along the navigation channel near Kalskag (downriver from BTC), overall impacts of transportation facilities would be considered moderate.

3.13.3.5.3 NATURAL GAS PIPELINE

Under Alternative 4, direct and indirect effects to fish and aquatic resources from construction, operation, and abandonment/closure of the natural gas pipeline would be the same as described for Alternative 3A.

3.13.3.5.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 4

Under Alternative 4, the upriver extent of barge traffic on the Kuskokwim River would be reduced by about 69 miles. This would eliminate the need for barge traffic in some areas where the river channel tends to be more confined. Although potential impacts from tug propeller forces on rainbow smelt eggs incubating in spawning areas near Kalskag would be similar to Alternative 2, some of the potential impacts on fish and aquatic habitat along shoreline areas would occur at a lower intensity. This is because the channel between Kuskokwim Bay and BTC Port Site is generally wider than it is farther upriver to the Angyaruaq (Jungjuk) Port site under Alternative 2. Also, compared to Alternative 2 there would be 10 fewer stream crossings along the mine access road under this alternative reducing the potential risks of stream sedimentation and water quality impacts from road construction and maintenance as well as fewer culverts to maintain. This would be offset, however, from proportionately greater risks of erosion, runoff, and sedimentation from construction and operation of a roadway that would be 43 miles longer than Alternative 2. The combined effects of construction and operation of the roadway would result in a proportionately greater increase in potential water quality and habitat degradation that could adversely affect anadromous and resident fish populations in the Owhat River drainage as compared to Alternative 2. Therefore, the net overall direct and indirect impacts for Alternative 4 also would range from minor to moderate, similar to Alternative 2. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. If mitigation and monitoring measures from Alternative 2 were adopted and required, the summary impact rating for the mine site and transportation facilities would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The impacts from the transportation facilities and the natural gas pipeline would remain minor to moderate.

3.13.3.6 ALTERNATIVE 5A – DRY STACK TAILINGS

3.13.3.6.1 MINE SITE

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the mine site based on the use of a dry stack tailings method would be similar to what has been described for Alternative 2 where the subaqueous tailings storage method would be used. The reduced storage requirements within the TSF, however, would lessen the risk of potential dam failure and downstream release of slurry materials to Anaconda and Crooked creeks.

3.13.3.6.2 TRANSPORTATION FACILITIES

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of transportation facilities based on mining operations using a dry stack tailings method would be similar to what has been described for Alternative 2.

Although there would be an increased demand for diesel fuel and consumables under this alternative, this would result in a minimal increase in barge traffic and associated effects on fish and aquatic resources over that described under Alternative 2.

3.13.3.6.3 NATURAL GAS PIPELINE

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the natural gas pipeline based on the use of a dry stack tailings method would be similar to what has been described for Alternative 2.

3.13.3.6.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 5A

Under Alternative 5A, direct and indirect effects to fish and aquatic resources from construction, operation, and closure of the mine site, transportation facilities, and natural gas pipeline based on the use of a dry stack tailings method would be similar to what has been described for Alternative 2. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. If mitigation and monitoring measures from Alternative 2 were adopted and required, the summary impact rating for the mine site and transportation facilities would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The impacts from the transportation facilities and the natural gas pipeline would remain minor to moderate.

3.13.3.7 ALTERNATIVE 6A – MODIFIED NATURAL GAS PIPELINE ALIGNMENT: DALZELL GORGE ROUTE

3.13.3.7.1 MINE SITE

Under Alternative 6A, direct and indirect effects to fish and aquatic resources at the mine site would be similar to what has been described for Alternative 2.

3.13.3.7.2 TRANSPORTATION FACILITIES

Under Alternative 6A, direct and indirect effects to fish and aquatic resources associated with transportation facilities would be similar to what has been described for Alternative 2.

3.13.3.7.3 NATURAL GAS PIPELINE

Under Alternative 6A, the pipeline route would depart to the northwest from the Alternative 2 alignment at about MP 106.5. Overall, ground disturbance impacts would be similar to Alternative 2 ranging in intensity from low to high. This route would cross Happy River and the South Fork of the Kuskokwim River using HDD to minimize soil and streambed disturbance. There would be slightly fewer (22 compared to 28) stream crossings at sites with permafrost/erodible soils and confirmed or potential fish presence under this alternative compared to Alternative 2. Potential direct and indirect effects on fish and aquatic resources would be similar to Alternative 2 and would involve potential habitat degradation from stormwater runoff, suspended solids, and reduced flows caused by disturbed soils and water withdrawals for ice-road construction. Such impacts would be of low to medium intensity and

localized, occurring on a temporary to long-term basis. The context of such impacts would be important relative to stream reaches that are crossed by the pipeline ROW that are classified as EFH under the Magnuson-Stevens Act. Therefore, anticipated effects from pipeline construction and operation under Alternative 6A would range from minor to moderate.

3.13.3.7.4 SUMMARY OF IMPACTS FOR ALTERNATIVE 6A

Under Alternative 6A, direct and indirect impacts affecting fish and aquatic resources as a result of the construction, operation, abandonment, and reclamation of the natural gas pipeline aligned through the Dalzell Gorge Route would be considered minor to moderate, similar to Alternative 2. The effects determinations take into account applicable impact reducing design features and BMPs, as discussed in Alternative 2. If mitigation and monitoring measures from Alternative 2 were adopted and required, the summary impact rating for the mine site and transportation facilities would be the same as Alternative 2. Impacts associated with climate change would also be the same as those discussed for Alternative 2. The impacts from the transportation facilities and the natural gas pipeline would remain minor to moderate.

3.13.3.8 IMPACT COMPARISON – ALL ALTERNATIVES

A comparison of potential impacts among alternatives is presented in Table 3.13-31 below.

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Table 3.13-31: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alt. 2 – Proposed Action	Alt. 3A – LNG-Powered Haul Trucks	Alt. 3B – Diesel Pipeline	Alt. 4 – Birch Tree Crossing Port	Alt. 5A – Dry Stack Tailings	Alt. 6A – Dalzell Gorge Route
Mine Site						
Loss or alteration of instream habitat, fish and benthic biota	Minor to moderate impacts associated with 8 miles of instream habitat in five Crooked Creek drainages near the mine site.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Water quality as related to water management practices	Minor impacts in five tributaries in the MSA and in the middle and lower reaches of Crooked Creek.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Wetland and riparian buffer removal	Moderate impacts involving about 100 acres of riverine wetlands or river channel including about 5 miles of perennial streams and about 1 mile of intermittent streams.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Streamflow changes to off-channel aquatic habitat along Crooked Creek	Moderate to minor impacts in middle and lower reaches of Crooked Creek, respectively. Major impacts for middle and lower reaches of Crooked Creek under a <i>High K</i> scenario.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Streamflow changes to aquatic habitat in the mainstem channel of Crooked Creek	Moderate impacts in Crooked Creek near the MSA; minor impacts in lower Crooked Creek. Major impacts in these areas under a <i>High K</i> scenario.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Streamflow changes and salmon spawning habitat in Crooked Creek	Moderate impacts from redd dewatering near the MSA (American Creek to Crevice Creek); minor impacts in lower Crooked Creek. Major impacts in these areas under a <i>High K</i> scenario.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Streamflow changes and salmon spawning substrate freezing in Crooked Creek	Minor impacts near the MSA; negligible impacts in lower Crooked Creek. Major impacts in these areas under a <i>High K</i> scenario.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Streamflow changes and Crooked Creek salmon production	Moderate impacts near the MSA; negligible impacts in lower Crooked Creek. Major impacts in these areas under a <i>High K</i> scenario. Minor impacts to overall Kuskokwim River watershed.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.

Table 3.13-31: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alt. 2 – Proposed Action	Alt. 3A – LNG-Powered Haul Trucks	Alt. 3B – Diesel Pipeline	Alt. 4 – Birch Tree Crossing Port	Alt. 5A – Dry Stack Tailings	Alt. 6A – Dalzell Gorge Route
Stream temperature changes in Crooked Creek	Minor to moderate impacts near the MSA and minor in lower Crooked Creek.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Erosion and sedimentation	Minor to moderate impacts in the MSA including the middle reaches of Crooked Creek and negligible impacts in lower Crooked Creek.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Metals and mercury emissions	Moderate to minor impacts to wetlands and water in the MSA, Crooked Creek drainage, and nearby watersheds.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Transportation Infrastructure						
Vessel wave impacts on erosion and nearshore fish habitat	Minor impacts along narrow segments of the Kuskokwim River.	Minor impacts along narrow segments of the Kuskokwim River; impact probability reduced due to fewer fuel barge trips.	Minor impacts along narrow segments of the Kuskokwim River; impact probability reduced due to fewer fuel barge trips.	Minor impacts along narrow segments of the Kuskokwim River; impact extent is reduced due to shorter distance of barge trips and wider channel traveled.	Same as Alt. 2.	Same as Alt. 2.
Vessel wave impacts on water temperature and nearshore fish habitat	Minor impacts in confined channel segments and near tributary confluences.	Minor impacts along narrow segments of the Kuskokwim River; impact probability reduced due to fewer fuel barge trips.	Minor impacts along narrow segments of the Kuskokwim River; impact probability reduced due to fewer fuel barge trips.	Minor impacts along narrow segments of the Kuskokwim River; impact extent is reduced due to shorter distance of barge trips and wider channel traveled.	Same as Alt. 2.	Same as Alt. 2.
Fish displacement and stranding	Negligible to moderate along narrow segments of the mainstem Kuskokwim River.	Negligible to moderate along narrow segments of the mainstem Kuskokwim River; impact probability is reduced due to fewer fuel barge trips.	Negligible to moderate along narrow segments of the mainstem Kuskokwim River; impact probability is reduced due to fewer fuel barge trips.	Negligible to Minor along wider segments of mainstem Kuskokwim River; impact extent reduced with shorter distance of barge trips and wider channel.	Same as Alt. 2.	Same as Alt. 2.
Prop wash bed scour	Moderate to major (in shallow, narrow channels) impacts depending on depth, speed, location, and other factors associated with tug and barge traffic.	Moderate to major (in shallow, narrow channels) impacts depending on depth, speed, location, and other factors associated with tug and barge traffic; impact probability is reduced due to fewer fuel barge trips.	Moderate to major (in shallow, narrow channels) impacts depending on depth, speed, location, and other factors associated with tug and barge traffic; impact probability is reduced due to fewer fuel barge trips.	Moderate to major (in shallow, narrow channels) impacts depending on depth, speed, location, and other factors associated with tug and barge travel; impact extent is reduced due to shorter distance of barge trips.	Same as Alt. 2.	Same as Alt. 2.

Table 3.13-31: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alt. 2 – Proposed Action	Alt. 3A – LNG-Powered Haul Trucks	Alt. 3B – Diesel Pipeline	Alt. 4 – Birch Tree Crossing Port	Alt. 5A – Dry Stack Tailings	Alt. 6A – Dalzell Gorge Route
Propeller-induced fish injury and mortality	Negligible to moderate based on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character.	Negligible to moderate based on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character; impact probability is reduced due to fewer fuel barge trips.	Negligible to moderate based on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character; impact probability is reduced due to fewer fuel barge trips.	Negligible to minor based on time of year, time of day, fish life stages (and swimming ability), concentration of fish, and channel character; impact is reduced due to shorter distance of barge trips and wider channel traveled.	Same as Alt. 2.	Same as Alt. 2.
Mine access road construction, operations and maintenance	Minor impacts along roadway and at bridge and culvert crossings.	Minor impacts along roadway and at bridge and culvert crossings; less maintenance due to reduced fuel deliveries.	Minor impacts along roadway and at bridge and culvert crossings; less maintenance due to reduced fuel deliveries.	Minor impacts along roadway and at bridge and culvert crossings; higher probability of impacts due to a road distance twice as long as Alt 2.	Same as Alt. 2.	Same as Alt. 2.
Port site construction and operation	Moderate impacts to fish, aquatic habitat, and prey species.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Contamination and Small Spills	BMPs would reduce impacts to minor.	BMPs would reduce impacts to minor; fewer barge trips would reduce risk probability.	BMPs would reduce impacts to minor; fewer barge trips would reduce risk probability.	BMPs would reduce impacts to minor; risk of spills on river upstream of Birch Tree Crossing would be eliminated, but increased risk of spills on land are possible due to longer mine access road.	Same as Alt. 2.	Same as Alt. 2.
Pipeline						
Construction of stream crossings	Minor to moderate impacts to fish, aquatic habitat, and prey species.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Construction of pipeline and related infrastructure including temporary and long-term access roads	Minor to moderate impacts to fish, aquatic habitat, and prey species; increased fishing access along construction roads.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Water withdrawals for ice road construction, pipeline testing, and related discharges	Minor impacts to local streams and aquatic habitat.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Impacts from operation, closure, and reclamation of access roads, material borrow sites, and related infrastructure	Minor to moderate impacts to local streams and aquatic habitat.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.
Contamination and Small Spills	BMPs would reduce impacts to minor.	Same as Alt. 2.	Risks of spills and contamination are higher for diesel than for natural gas.	Same as Alt. 2.	Same as Alt. 2.	Same as Alt. 2.

Table 3.13-31: Comparison of Impacts by Alternative*

Impact-causing Project Component	Alt. 2 – Proposed Action	Alt. 3A – LNG-Powered Haul Trucks	Alt. 3B – Diesel Pipeline	Alt. 4 – Birch Tree Crossing Port	Alt. 5A – Dry Stack Tailings	Alt. 6A – Dalzell Gorge Route
Impact Conclusion						
	Moderate impacts from stream habitat and fisheries losses in Crooked Creek tributaries at the MSA; streamflow reductions in Crooked Creek near the MSA (major in a <i>High K</i> scenario); potential barge-related fish displacement, stranding, and injuries or mortalities and riverbed scour (major in confined and shallow segments of the Kuskokwim River); and aquatic habitat impacts from construction of the new port site, pipeline, and its infrastructure. Additionally, temporary runways, access roads, and trails along the pipeline would result in greater harvest and angler competition for select fish populations in streams and rivers. <u>Impact Level:</u> Moderate	Reduced barge-related impacts due to fewer fuel barge shipments on the Kuskokwim River, otherwise similar impacts and impact levels as Alternative 2. <u>Impact Level:</u> Moderate	Reduced barge-related impacts due to fewer fuel barge shipments on the Kuskokwim River; diesel pipeline would result in a higher probability of habitat contamination from potential spills; otherwise similar impacts and impact levels as Alternative 2. <u>Impact Level:</u> Moderate	Reduced barge-related impacts from shorter distance traveled to alternative port site; increased impacts to aquatic habitat along alternative mine access road that would be twice as long; otherwise same impacts and impact levels as Alternative 2. <u>Impact Level:</u> Moderate	Same as Alt. 2. <u>Impact Level:</u> Moderate	Same as Alt. 2. <u>Impact Level:</u> Moderate

Notes:
* The No Action Alternative would have no new impacts on Fish and Aquatic Resources.